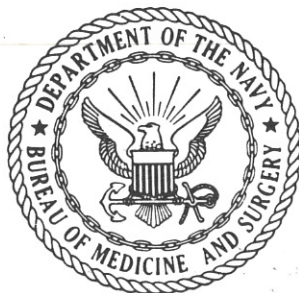


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RADIATION HEALTH PROTECTION MANUAL

NAVMED P-5055



DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
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INTRODUCTION

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1-1. Purpose

A radiation health protection program may be defined as the sum of all the methods, plans, and procedures used to protect the health and environment of personnel from exposure to sources of ionizing radiation. A radiation health protection program is not an end in itself; its purpose is to provide the means to preserve and maintain the health of personnel while they accomplish necessary and purposeful work in or around areas contaminated with radioactive material or in fields of ionizing radiation.

1-2. Scope

The regulations contained herein are intended for observance during peacetime by all naval activities possessing or utilizing sources of ionizing radiation which may affect the health of personnel. These standards do not apply to the exposure of an individual to sources of ionizing radiation when used for the diagnosis or treatment of medical or dental conditions of that individual. Personnel not under the control of the Navy Department shall comply in all respects with these regulations when engaged in a Navy-sponsored program or operation. It is recognized that these regulations may not be applicable to procedures initiated after an attack in which nuclear weapons are utilized; however, the provisions of these regulations, insofar as they are feasible, shall remain in effect after such an attack.

1-3. Policy

The potentially serious nature of radiation hazards calls for the most scrupulous observance of precautions. It is the stated policy of the Department of Defense that personnel exposure to ionizing radiation shall be reduced to a minimum. Positive efforts shall be made to fulfill this objective without a reduction in the operational and training efforts. Adequate indoctrination and training in radiation safety practices and protective measures are essential and required for all personnel engaged in work in which

they may be subject to exposure to sources of ionizing radiation.

It is particularly important that persons directly responsible for working parties be aware of their specific responsibilities with regard to the execution of safety and protective measures. In addition, it is mandatory that rigid discipline be exercised to ensure that proper instruction and protective equipment are available to and utilized by all involved personnel. When radiological safety measures are properly executed, the risk associated with occupational radiation exposure is negligible when compared to other risks normally encountered.

1-4. Responsibility

(1) *General.*—Basic regulations regarding handling of radiation sources are promulgated by the Department of Health, Education, and Welfare and the Atomic Energy Commission. Manuals, procedures and detailed instructions are promulgated by the various naval offices and bureaus, commanders in chief, type and force commanders, and commanding officers.

(2) *Naval Offices and Bureaus.*—

(a) The Chief of Naval Operations and the Commandant of the Marine Corps exercise overall coordination and policy control of the naval radiation programs under their cognizance in the fields of organization, equipment, safety, personnel qualifications, assignments, and training.

(b) The Bureau of Medicine and Surgery is responsible for:

- (1) Developing physical standards for personnel.
- (2) Applying established radiation protection standards and guides.
- (3) Investigating physiological effects of radiation.
- (4) Treating radiation casualties and occupational overexposures.
- (5) Developing radiation health protection, personnel dosimetry, and radiological

safety programs unless otherwise specified below.

- (6) Recommending training programs and qualification standards for personnel involved in radiation health protection programs.

(c) The Bureau of Naval Personnel is responsible for establishing training programs, qualification standards, and assignments.

(d) The Naval Air Systems Command is responsible for:

- (1) Development of equipment other than radiac and methods for individual and collective protection of personnel in aircraft.
- (2) Application of equipment and methods for radiological decontamination of aircraft.
- (3) Development of methods and equipment for handling nuclear weapons.
- (4) Logistic support and transportation of nuclear weapons.

(e) The Naval Ship Systems Command is responsible for the radiological safety programs for naval nuclear propulsion plants including responsibilities for procedures for the possession, use, and disposal of radioactive materials associated therewith.

(f) The Naval Supply Systems Command is responsible for the application of Navy methods and procedures for the possession, use, disposal, handling and accountability of radioactive materials (other than weapons) in the Supply System and at Naval Supply Systems Command activities.

(g) The Naval Facilities Engineering Command is responsible for:

- (1) Procuring equipment other than radiac for individual and collective protection of personnel ashore with the exception of equipment associated with naval nuclear propulsion plants.
- (2) Applying methods and equipment for decontamination ashore with the exception of equipment associated with naval nuclear propulsion plants.
- (3) Modifying firefighting, cleanup, and demolition techniques as necessary.
- (4) Reactor safety programs for shore-based reactors.
- (5) Provide for a unified approach to radiological affairs support within the Naval Material Command and for technical support to fleet operating forces and other components of the Navy.

(h) Naval Electronic Systems Command is responsible for:

- (1) The development and procurement of radiac instruments and systems. Radiac equipment is defined as any equipment used to detect or measure nuclear radiation. Included are specialized equipments used for test or calibration of radiac equipments. Not included

are equipments for nuclear reactor control and instrumentation and equipments used in the film badge program.

- (2) Procedures for possession, use and disposal of radioactive materials (other than weapons and naval nuclear reactors and equipment associated therewith) used by activities of the Naval Ship Systems Command and the Naval Electronic Systems Command.

(3) *Command.*—The commanding officer or officer in charge of a Naval or Marine Corps activity is responsible for compliance with federal regulations and Navy Department directives in the procurement, control of storage, handling, use, safety aspects, and disposal of radioactive material under his jurisdiction.

Major commanders having command jurisdiction over installations and activities using radiation sources shall take such action as is deemed necessary to establish uniform practices and procedures by subordinate commanders and to assure compliance and implementation of the Federal Regulations, Department of Defense directives, and Department of the Navy directives. Periodic inspection shall be conducted to assure compliance with the applicable directives. Commanders having jurisdiction over installations and activities using AEC licensed radiation sources shall ensure that all applicable provisions of the licenses and of Title 10, Code of Federal Regulations, are complied with in the use of these sources.

1-5. Definitions

(1) *Radiation Sources.*—Any material, equipment or devices which generate or are capable of generating ionizing radiation, including naturally occurring and artificially induced radioactive materials; special nuclear materials; contaminated material; nuclear reactors, particle generators, and accelerators; medical, dental, and industrial radiographic and fluoroscopic equipment; and electromagnetic wave generators capable of producing ionizing radiation.

(2) *Ionizing Radiation.*—The electromagnetic or particulate emanations produced by radiation sources. These emanations can cause ionization, i.e., the ejection of electrons from atoms. Ionization within the cells or tissues of the body can occur as the result of exposure to alpha particles, beta particles (electrons), neutrons, protons, or other atomic or subatomic particles; or gamma rays, x-rays, or other electromagnetic waves with sufficient energy to eject electrons from atoms.

(3) *Dose Equivalent (DE).*—The product of the absorbed dose (D), the quality factor, (QF), the dose distribution factor, (DF), and other necessary modifying factors. The dose equivalent is numerically equal to the dose in rads multiplied by the appropriate modifying factors. $DE = (D \times QF \times DF \times \dots)$. The unit of dose equivalent is the rem.

(4) *Rem.*—An equivalent dose of ionizing radiation in terms of its estimated biological effect, relative to an absorbed dose of one roentgen of high

voltage X-rays. The rem shall be the unit of dose for record purposes.

(5) *Rad.*—The unit of absorbed dose which is equal to the absorption of energy in the amount of 100 ergs/gram of any material. For the purpose of these regulations, one Rad is considered to be the dose delivered by one Roentgen of X or gamma radiation.

(6) *Roentgen (R).*—That amount of x-ray or gamma radiation which will produce in air 2.58×10^{-4} Coulombs per kilogram of air.

(7) *Quality Factor (QF).*—That factor which is multiplied by the absorbed dose to obtain a quantity which equates to a common scale the dose equivalent (DE) of any type of ionizing radiation to which an individual is exposed. For the purpose of these regulations, the dose equivalent for each type and energy level of ionizing radiation shall be determined by using the following quality factors:

(a) For X-, gamma- or beta-radiation, use a quality factor equal to one unless otherwise approved by BUMED.

(b) For neutrons of unknown energy and for protons, use a quality factor equal to 10.

(c) For ionizing particles heavier than protons and with sufficient energy to reach the lens of the eye, use a quality factor equal to 20.

(d) For neutron fluxes when the energy distribution of the neutrons is known, consult Title 10, Part 20 of the Code of Federal Regulations.

(8) *Radioactive Contamination.*—A radioactive substance dispersed in materials or places where it is undesirable. An object or area is considered to be contaminated when the loose radioactive surface contamination (excluding fallout) exceeds 450 micro-microcuries of beta gamma activity or 50 micro-microcuries for alpha activity as measured on a dry filter paper wiped over an area of 100 square centimeters, unless a different limit is approved by the AEC for licensees, or by Chief BUMED for users of sources which are not licensed by the AEC.

(9) *Unrestricted Area.*—Unrestricted area means any area access to which is not controlled by the activity for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

(10) *Radiation Area.*—Any area to which access shall be limited as deemed necessary by cognizant authority and in which appropriate precautionary measures are taken to protect personnel from exposure to radiation or radioactive materials. A radiation area includes any area accessible to personnel to which there exists:

(a) Ionizing radiations at such dose-rate levels that a major portion of the body, head and trunk, active blood-forming organs, gonads, or lens of the eye could receive in any one hour a dose of five mrem, or in any five consecutive days a dose in excess of 100 mrem.

(b) Airborne radioactivity levels in excess of the amounts specified for a 40-hour week in Table I, Column I of Appendix B in Title 10, Part 20 of the Code of Federal Regulations.

(11) *High Radiation Area.*—Any area accessible to personnel in which there exists ionizing radiation at such levels that a major portion of the body, head and trunk, active blood-forming organs, gonads, or the lens of the eye could receive in any one hour a dose in excess of 100 mrem.

(12) *Radiation Health Program.*—A medical department responsibility comprising all methods and procedures designed to maintain and protect the health of personnel exposed to ionizing radiation or radioactive contamination. It includes, but is not necessarily limited to the following:

(a) Detection and identification of radiation and contamination hazards.

(b) Determination, evaluation and documentation of personnel exposures (both internal and external).

(c) Medical examinations of personnel before, after and during periods of radiation exposures.

(d) Evaluation of environmental monitoring and radiation control procedures related to radiation health and to the submission of recommendations as required.

(e) Review of training and qualification requirements of personnel handling radioactive materials, or working in radiation areas, as applicable to radiation health.

(f) Conducting radiation health training for involved personnel as necessary.

(g) Ensuring compliance with BUMED and other relevant instructions in the area of radiation health.

(h) Submission of required reports and maintenance of applicable records.

(i) Assistance, as required, in the radiation health aspects of nuclear accident preparedness, NBC Warfare Defense, or disaster control planning.

(j) Promotion of a high state of awareness and compliance with radiation health precepts.

(13) *Calendar Quarter.*—A calendar quarter means any period determined according to either of the following subdivisions referred to in the Code of Federal Regulations, Title 10, Part 20.3 (a) 4.

(a) The first period of any year may begin on any date in January; provided that the second, third and fourth periods accordingly begin on the same date in April, July, and October, respectively, and that the fourth period extend into January of the succeeding year, if necessary to complete a three-month quarter.

(b) The first period in a calendar year of 13 complete, consecutive calendar weeks; the second period in a calendar year of 13 complete, consecutive calendar weeks; the third period in a calendar year of 13 complete, consecutive calendar weeks; the fourth period in a calendar year of 13 complete, consecutive calendar weeks.

Alternatively, the four periods may consist of the first 14 complete, consecutive calendar weeks; the next 12 complete, consecutive calendar weeks; the next 14 complete, consecutive calendar weeks; and the last 12 complete, consecutive calendar weeks.

(c) Naval facilities using staggered periods for measuring and reporting radiation exposures should include film badge readings taken up to and including 15 January in the previous annual calendar year report and readings taken after 15 January should be assigned to the subsequent calendar year photosimetry report. The utilization of a uniform, specified calendar year report is required in order to avoid duplication of data transcribed to a data processing readout.

(14) *Radiation Health Officer.*—A Medical Service Corps Officer (NOBC Classification 0886) or similarly designated officer or civilian who is qualified by virtue of his education, military training, and/or professional experience, to supervise a Radiation Health Program. He normally will function within the Medical Department of a ship or station and will not normally be assigned responsibilities in Radiation Safety or Control, except within BUMED Management Control Activities. The Radiation Health Officer shall plan, supervise, and administrate the Radiation Health Program. He shall be a member of the Ionizing Radiation Control Committee, as described in article 4-1 (1) and shall advise the Command as to hazards associated with radiation and the effectiveness of control measures.

(15) *Radiological Safety or Control Programs.*—All procedures and techniques which are utilized for storage, handling, operation, shipping, or disposal of radiation sources, or for controlled access to radiation sources, or to enforce the approved recommendations relating to the radiation health protection programs. Medical department personnel shall not normally be assigned duties and responsibilities in radiological safety except within BUMED management control activities.

(16) *Radiological Safety Officer.*—An individual who shall be appointed by the unit commander to provide consultation and advice regarding the implementation of controls for the hazards associated with

radiation sources and the effectiveness of these measures. He shall be responsible to the unit commander for promulgating and supervising the radiological safety program. He is directly responsible for the adequate and effective controls which prevent spread of contamination and for decontamination techniques and procedures. He shall be appointed to the Ionizing Radiation Control Committee described in article 4-1 (1). This individual shall be technically qualified by virtue of education, military training and/or professional experience to supervise the storage, issue, operation and disposition of radiation sources, and shall have a thorough knowledge of applicable regulations pertaining to the control of radioactivity, prior to appointment.

The terms "Radiation Safety Officer," or "Radiological Control Officer," may be used in lieu of "Radiological Safety Officer."

(17) *Members of the General Public.*—For the purpose of this manual, individuals not occupationally exposed to ionizing radiation shall be considered members of the general public.

1-6. Radiation Health Program Evaluation

To ensure that the regulations and procedures specified herein are appropriately complied with, evaluations of radiation health programs shall be conducted at least semi-annually. For forces afloat, these audits shall normally be made by Squadron Medical Officers. Shore based organizations should conduct their own audits by utilizing personnel as inspectors who are knowledgeable in the radiation health field, but who are as independent as possible from the local radiation health program. The custodian of the Health Record shall insure that any corrections or additions being made to the Health Record conform to the stated requirements in MANMED 16-18. (7). Reports of these audits should be retained and be available for review by BUMED.

Chapter 2

MEDICAL EXAMINATIONS

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2-1. Preplacement Medical Examinations

(1) *Personnel Involved.*—All personnel who are being considered for routine or occasional assignment to duties or occupations requiring exposure to ionizing radiation or the handling of radioactive materials shall be given a medical examination prior to assignment or transfer to those duties or occupations. Personnel who are not routinely exposed to ionizing radiation during their normal occupation, i.e. visitors, including messengers, service men, and deliverymen, (individuals whose exposure is truly sporadic), are not required to have preradiation exposure medical examinations provided they are not likely to exceed 500 mrem per year or 125 mrem per quarter.

(2) *Scope.*—The preplacement examination shall include, but not be limited to, a careful history, complete and thorough physical examination, chest x-ray, baseline blood study, and other clinical laboratory studies and bioassays as indicated. If a physical examination has been conducted within the past 6 months, it may be accepted in whole or in part, at the discretion of the cognizant medical officer, in lieu of the corresponding sections of the preplacement examination, provided a record of such examination is available in the individual's Health Record (military), or Industrial Health Jacket (civilian).

Exception: Results of chest x-rays and/or urinalysis performed within the previous 12 months may be accepted at the discretion of the cognizant medical officer.

(a) *Medical History.* A complete medical history shall be obtained in accordance with the appropriate sections of MANMED chapter 15 or FedPerMan chapter 339. In addition to the medical history requirements of MANMED chapter 15 or FedPerMan chapter 339, the following histories on naval personnel and civilian employees who have received medical or dental therapeutic radiation shall be submitted to Code 74, Bureau of Medicine and Surgery for evaluation by a Medical Advisory Board:

(1) Industrial history to determine the amount of ionizing radiation previously received as the result of occupational exposure.

(2) Past medical history to evaluate any previous malignancies and blood dyscrasias.

(3) A history of medical or dental therapeutic radiation estimating the amount of ionizing radiation previously received for medical or dental therapy shall be elicited and appropriately recorded.

(4) Family history to elicit the presence of malignancies, blood dyscrasias, congenital defects, sterility, cataracts, etc., in parents, siblings, and collateral lines.

(b) *Physical Examination.* A complete and thorough physical examination shall be conducted in accordance with MANMED chapter 15 or FedPerMan chapter 339, as applicable. Careful inspection shall be accomplished to elicit evidence of precancerous and cancerous skin lesions, lymphoma, Hodgkin's disease, blood dyscrasias, lenticular opacities, etc., which might also be produced or aggravated by exposure to ionizing radiation. Special attention shall be accorded to the following:

(1) *Eye Examinations.* The medical examiner shall perform an ophthalmoscopic examination on all personnel. A careful inspection shall be made to establish the presence of any corneal nebulas, masclusas, or leucomas, chronic corneal ulcers, chronic or recurrent keratitis, lenticular opacities, etc., which might be misinterpreted on a subsequent medical examination as lesions resulting from exposure to ionizing radiation. If lenticular opacities are identified, a standard slit lamp examination will be conducted.

(2) *Slit Lamp Examinations.* A slit lamp examination need be conducted on only those personnel whose ophthalmoscopic examination has identified a lenticular opacity or on those personnel who have received or are extremely likely to receive to the lens of the eye a dose of ionizing radiation in excess of 5 rem, or a dose of neutrons in excess of 1 rem, during the subsequent year or who are assigned duties within the radiation areas of particle accelerators, or experimental or research reactors; and on all others deemed necessary by the cognizant medical officer. Slit lamp examinations shall be conducted by an ophthalmologist, optometrist, or medical officer experienced in the use of the slit lamp. When adequate

slit lamp examinations cannot be accomplished within the local command, these examinations shall be completed in accordance with the instructions contained in article 3-1 of this manual.

(c) *Laboratory Procedures.* Laboratory tests shall include, as indicated:

(1) *Chest X-ray.* To reduce medical exposure to ionizing radiation, a 14 x 17 inch chest x-ray shall be taken on all personnel as part of the preplacement medical examination, rather than a 70 mm. photofluorogram.

(2) *Blood Study.* A baseline blood study consisting of a hemoglobin determination, total white cell and differential count and a hematocrit determination shall be made. Table I lists the "normal" values for these blood constituents. Since universal agreement on normal values is lacking, this table is presented as a guide.

TABLE I
NORMAL BLOOD CONSTITUENTS

Blood constituents	Male	Female
Hemoglobin	13-18 gms	12-17 gms
Hematocrit	40-54	37-47
Leukocytes	4,000-12,000	4,000-12,000
Neutrophils	55-80%	55-80%
Lymphocytes	20-45%	20-45%
Bands and juveniles	0-10%	0-10%

(3) *Urinalysis.* A routine urinalysis shall be performed on all individuals. When deemed necessary by the cognizant medical officers, a radiochemical urinalysis shall be performed on personnel who have previously engaged in handling radioactive material not hermetically sealed. When radiochemical urinalysis cannot be accomplished within the local command, urine samples shall be collected and shipped to the appropriate medical support facility in accordance with the instructions contained in article 3-2 of this manual.

(4) *Radon Breath Sample.* Breath samples to determine the concentration of radon in expired air shall be obtained from all personnel who have been or will be engaged in handling radium (or its compounds) which is not hermetically sealed. These breath samples shall be collected and shipped to the medical support facility in accordance with the instructions contained in article 3-3 of this manual.

(5) *Bioassays.* In addition to radiochemical urinalysis and breath measurements for radon activity; whole body radiation counts, body scanning with a scintillation counter and other bioassay techniques for the determination of radioactivity in body tissues, secretions, and excretions can be performed as required by competent medical authority. When deemed necessary by the cognizant medical officer of a ship, unit, or command which lacks the capability to perform body counts, scanning, or bioassays, a request should be submitted by that ship, unit, or command to the nearest designated support facility for approval and assistance in obtaining these tests in accordance with the instructions in Chapter 3 of this manual.

Internal contamination should be assessed by whole body counting or scanning techniques.

(3) *Medical Requirements.*—The general medical requirements include those which are required for active duty in the military service or for civil service employment as defined in MANMED and FedPerMan, respectively. In addition to failure to meet the general medical requirements, the following are considered disqualifying:

(a) *Medical History.* Any history of occupational radiation exposure in excess of that allowed by article 4-3 (4) of this instruction or the instruction applicable at the time of exposure, or any evidence of previous radiation injury which is considered disqualifying by the medical examiner shall be evaluated by Code 74, Bureau of Medicine and Surgery.

(b) *Physical Findings.* The presence of any physical condition such as precancerous and cancerous skin lesions, chronic corneal ulcers, cataracts, bleeding tendencies, or any other condition which might, in the opinion of the cognizant medical officer, be aggravated by or attributed to occupational exposure to ionizing radiation, shall be evaluated for disqualification. An individual who has an open wound (whether laceration, abrasion, or ulceration) is disqualified from handling radioactive materials which are not hermetically sealed unless the wound is adequately protected from radioactive contamination or until such time as the medical examiner considers that the wound is sufficiently healed.

(c) *Laboratory Procedures.* From the results of the laboratory tests, the decision to disqualify an individual shall be based on the following considerations:

(1) *Hematology.* Any deviation from the normal hematological values enumerated in table I shall be evaluated by the cognizant medical officer. In cases where abnormalities may be due to transient disease or other temporary conditions, the individual may be temporarily disqualified by the medical officer. A reexamination shall be made after the individual has recovered from the illness. No one shall be qualified for exposure to radiation when, in the opinion of the cognizant medical officer, a gross hematological abnormality exists.

(2) *Bioassays.* The presence of plutonium, uranium, radioactive rare earths or other biologically long-lived isotopes in the body or in the urine or other bioassay material shall be carefully evaluated by the medical officer. Whole body counting techniques should be utilized to detect internal radioactive contamination. If it is likely that the individual has in excess of 100 percent of his maximum permissible body burden for any of these radioactive materials, as defined in National Bureau of Standards Handbook 69, he shall be disqualified from performing duties in a radiation area. If it is determined that the individual has a measurable body burden greater than 10 percent but less than 100 percent of the maximum permissible body burden, he may be permitted to perform duties in a radiation area when approved by the Bureau of Medicine and Surgery, Code 74.

(3) *Breath.* The presence of more than 5×10^{-13} curies of radon per liter of expired air is disqualifying.

(4) *Records.*—The results of the preplacement examination shall be recorded on NAVMED 6150/2 and the SF 600 for military personnel, and the SF 600 for civilian personnel. It shall be clearly stated whether the individual is qualified for occupational exposure. A suggested overprint of Standard Form 600 is included in Appendix A for a guideline to be used in recording the radiation physical examination.

(a) *Physical Examination.* In addition to all other physical findings, the following information shall be recorded:

(1) *Eye Examinations.* All abnormalities noted in the ophthalmoscopic examination shall be described in detail and recorded diagrammatically on Standard Form 600 (Chronological Record of Medical Care), which is to be clearly marked: "TO BE RETAINED PERMANENTLY IN HEALTH RECORD."

(2) *Slit Lamp Examination.* The results of the slit lamp examination shall be recorded on the Standard Form 600, which is to be clearly marked: "TO BE RETAINED PERMANENTLY IN HEALTH RECORD." All abnormalities shall be described in detail and recorded diagrammatically.

(b) *Laboratory Procedures.* The result of the laboratory tests shall be recorded as follows:

(1) *Blood Study.* The results of the baseline blood study shall be recorded on a Standard Form 600, which is to be clearly marked: "TO BE RETAINED PERMANENTLY IN HEALTH RECORD."

(2) *Bioassays.* The results of all radiochemical urinalysis, radon breath samples, whole body counts, and other bioassays shall be recorded on a Standard Form 600, which is to be clearly marked: "TO BE RETAINED PERMANENTLY IN HEALTH RECORD."

2-2. Periodic Reexaminations

(1) *Frequency.*—All personnel who perform their normal duties or occupations in a radiation area, or who occasionally enter a high radiation area in the normal course of their duties or occupations shall be given a radiation physical examination every 3 years. Individuals who receive less than 500 mrem each year are exempted from periodic reexaminations. Personnel receiving greater than 5 Rem radiation exposure during the previous calendar year shall be examined annually. All persons occupationally exposed to ionizing radiation shall be given a radiation physical examination at the termination of their employment.

(2) *Scope.*—The periodic reexamination may be used in conjunction with, or as part of an annual, promotion, reenlistment, retirement, or other physical examination. At the discretion of the cognizant medical officer, any portion of an annual, promotion, reenlistment, retirement, or other physical examination conducted within the previous six months may be used in lieu of the corresponding section of the periodic examination. That portion of any physical

examination required for the periodic reexamination of a radiation worker shall include, but not be limited to, an interval history, physical examination and blood count. A history of receiving medical or dental therapeutic radiation while employed as an industrial radiation worker shall be submitted to Code 74, Bureau of Medicine and Surgery for evaluation by a Medical Advisory Board in accordance with the requirements of paragraph 2-1. Medical officers shall assure that therapeutic radiation exposures and other medical problems which could disqualify the individual from radiation work are brought promptly to their attention without waiting for the next physical exam.

(a) *Medical History.* The medical history may be limited to that interval of time since the last radiation physical examination. Examiners should be alert for symptoms of chronic radiation illness such as fatigue, malaise, anorexia, and anxiety regarding exposure to radiation.

(b) *Physical Examination.* The physical examination shall include a careful inspection to detect the presence of weight loss; corneal or lenticular opacities; dryness, cracking, atrophy, depigmentation, ulceration, precancerous or cancerous lesions of the skin, especially of the hands and face; excessive longitudinal corrugation and brittleness of the fingernails; and any other signs of injury which could arise from exposure to ionizing radiation.

(c) *Laboratory Procedures.* Laboratory tests shall include:

(1) *Hematology.* The blood count shall consist of a total white cell and differential count, and a hematocrit and hemoglobin determination. Any deviation from the individual's baseline blood study shall be evaluated by the cognizant medical officer.

(2) *Exception.* Slit lamp examinations, chest x-rays, routine urinalysis, radiochemical urinalysis, breath samples, and other bioassays are not considered an essential part of a routine reexamination for radiation exposure, but may be included at the discretion of the medical officer. If conducted, slit lamp examinations, radiochemical urinalysis or whole-body scans and radon breath samples shall be performed in accordance with article 2-1 (2) (b) of this manual. When a periodic chest x-ray is required, a 14 x 17 inch chest film shall be used rather than a 70 mm photofluorogram.

(3) *Physical Requirements.*—The general physical requirements are those for continuation on active duty in the military service or in civil service employment as defined in MANMED or FedPerMan, as appropriate. In addition to failure to meet the general physical requirements for retention in the military service or for civil service employment, any evidence which, in the opinion of the cognizant medical officer, is indicative of radiation injury, shall be considered disqualifying. Any deviation in the results of the laboratory tests which do not conform with the guidelines given in article 2-1 (3) shall be considered disqualifying.

(4) *Records.*—The results of the periodic radiation examinations shall be recorded on Standard Form 600 and NAVMED 6150/2 in the individual's Health Record, or the Industrial Health Jacket, in accordance with

paragraph 2-1 (4) of this manual. It shall be clearly stated whether the individual is qualified or disqualified for occupational exposure. A suggested overprint of Standard Form 600 is included in appendix A for a guideline to be used in recording the radiation physical examination.

2-3. Special Examinations

(1) *Slit Lamp Examinations.* Slit lamp examinations shall be performed annually on all personnel who have received in excess of 5 rem of ionizing radiation or in excess of 1 rem of neutron radiation to the lens of the eye during the preceding year or as deemed necessary by the cognizant medical officer. The results of slit lamp examinations shall be recorded in detail and diagrammatically on Standard Form 600, which is to be clearly marked: "TO BE RETAINED PERMANENTLY IN HEALTH RECORD."

(2) *Bioassays.* When deemed necessary by the cognizant medical officer, a radiochemical urinalysis or other indicated bioassay shall be performed every six months on all personnel engaged in handling non-hermetically sealed plutonium, uranium, radioactive rare earths, or other long-lived radioisotopes, and on personnel having more than 25 percent of the maximum body burden for any of these radioactive substances. Urinalysis examinations are not useful in detecting insoluble ^{60}Co . The results of these bioassays shall be recorded in accordance with articles 5-2 and 5-3 and on a Standard Form 600, which is to be clearly marked: "TO BE RETAINED PERMANENTLY IN HEALTH RECORD."

(3) *Radon Breath Samples.*—Breath samples to determine the concentration of radon in expired air shall be obtained every 6 months from all personnel engaged in the handling of radium or its compounds which are not hermetically sealed. The results of

these breath samples shall be recorded in accordance with articles 5-2 and 5-3 and on a Standard Form 600, which is to be clearly marked: "TO BE RETAINED PERMANENTLY IN HEALTH RECORD."

(4) *Whole Body Counts.*—Whole body counting techniques should be utilized to detect internal gamma emitting contamination. The results shall be recorded in accordance with articles 5-2 and 5-3.

(5) *Termination Physical Examination.*—All persons occupationally exposed to ionizing radiation shall be given a radiation physical examination at the termination of their employment. Upon transfer from duties as a radiation worker an entry shall be made on Standard Form 600 that states: "Termination radiation physical examination required prior to release or retirement."

2-4. Emergency Examinations

(1) *Frequency.*—An emergency medical examination shall be given to any individual who has received in excess of 25 rem of ionizing radiation in a single dose, or has possibly ingested or inhaled a significant amount of radioactive material, or as deemed necessary by the cognizant medical officer.

(2) *Scope.*—The emergency medical examination shall include an interval history, physical examination, and any special clinical and laboratory examinations as indicated. A report describing the circumstances of overexposure shall be submitted to BUMED, Code 74, in accordance with the requirements of article 5-3.

(3) *Action.*—The cognizant medical officer may hospitalize the individual for further evaluation or treatment, or return him to his normal occupation or duties, subject to the limitations and restrictions as defined in chapter 4 of this manual. Also see section 3-4 of this manual.

Chapter 3

SUPPORT FACILITIES

	Article
Slit Lamp Examinations	3-1
Bioassays	3-2
Radon Samples	3-3
Assistance for Special Examinations and Treatment of Irradiated or Contaminated Personnel	3-4

3-1. Slit Lamp Examinations

(1) *Purpose.*—Slit lamp examinations are conducted on designated military and civilian personnel in the Naval Establishment to screen, detect, and record the earliest signs of lenticular opacities which may result from exposure to ionizing radiation, and to record preexisting or congenital lesions.

(2) *Procedures.*

(a) A qualified examiner, who may be either an ophthalmologist or an optometrist, civilian or military, shall be utilized to conduct and supervise this program. The eye examination shall include visual acuity tests, with and without corrective lenses, an ophthalmoscopic examination for retinal lesions and a slit lamp examination using the standard slit lamp, FSN 6515-584-5952, or an equivalent. If a ship, unit or command lacks facilities to perform such examinations, the cognizant medical officer shall request the nearest naval medical facility or other designated activity which has an examiner qualified to perform these examinations on designated personnel.

(b) The cost of implementing this program will be handled in the same manner as other medical costs at the support activity concerned. Services of civilian ophthalmologists or optometrists will be procured, if necessary, in accordance with current SECNAVINST 6260.1 and 7042.6 series.

3-2. Bioassays

(1) *Purpose.*—Whole body counting, scanning, and bioassays such as radiochemical urinalyses are performed to measure the amount of radioactivity present in an individual. These procedures may also be useful to evaluate the degree of internal radioactive contamination in individuals who are believed to have ingested or inhaled significant amounts of radioactive material.

(2) *Procedure.*—When deemed necessary by the cognizant medical officer of a ship, unit or command which lacks facilities to perform such analyses, the medical officer shall submit a request for a radiochemical urinalysis to the USAF Radiological

Health Laboratory (SGHW), Wright Patterson AFB, Ohio 45433; commercial telephone, area code 513, 257-6672, Autovon 787-6672. A copy of the request shall be submitted to BUMED (Code 74). The request shall include a general description of the event or circumstances which produced the possible internal radiation hazard, the probable radioisotopes present, the results of previous radiochemical urinalyses, and any other pertinent information.

(3) *Compliance.*—In compliance with the request, the support facility shall determine the need for the bioassay. When it has been determined that bioassays are needed, the support facility shall instruct the requesting activity regarding the collection, preservation, volume and number of specimens, and shipment procedures to be used, and shall supply appropriate containers and preservatives, if necessary.

3-3. Radon Samples

(1) *Scope.*—Radon activity is measured on samples of expired breath and on air samples from workroom, storage room and control areas.

(2) *Procedure.*—All workroom, storage room, control room, and breath samples shall be collected in flasks, obtained on written request, from the USAF Radiological Health Laboratory, Wright-Patterson AFB OH 45433. The request for flasks shall specify the number and type of samples to be taken, and shall include the name and telephone number of individual to contact for shipping date information. All flasks shall be used and returned to the USAF Radiological Health Laboratory within a period of approximately 2 weeks after receipt. If, for any reason, a flask has not been used within this period of time, it shall be returned and clearly marked "NOT USED."

(a) *Preparation of Flasks.*—All flasks will be shipped filled with nitrogen. They must be evacuated to approximately 29 inches Hg vacuum before use.

(b) *Control Room Samples.*—The control room shall be thoroughly ventilated for at least 10 minutes

prior to sample collection. Control samples shall be taken prior to the entrance of breath-sample subjects. Entry shall not be granted to anyone who has entered radium working or storage areas on that day, and only those specifically required in the collection of samples shall be permitted to enter the room until all specimens have been collected.

(c) *Breath Samples.*—All breath samples shall be taken at the beginning of the day before the involved personnel have entered the radium work or storage area. All routine and recheck breath samples shall be obtained on a day following two full days' absence from the radium workroom or storage areas. Each individual shall remain in the control room at least 10 minutes before his breath sample is collected:

(d) *Workroom and Storage Room Samples.*—Flasks received for workroom and storage room samples will be marked "For Workroom Air Only," and shall never be used for breath or control samples. Samples of workroom and storage room air shall be collected in the same manner as control samples, except that ventilation shall be the same as that normally supplied during working hours.

(e) *Special Samples.*—Special breath samples to determine possible ingestion or inhalation of excessive amounts of radium, can be arranged by telephone call to the USAF Radiological Health Laboratory (Commercial—(513)257-6672; Autovon—787-6672).

(3) *Shipping.*

(a) Radon samples must be measured within 7 days after sampling. Sampling should be planned so that shipments will arrive at the USAF Radiological Health Laboratory, Wright-Patterson AFB OH, before Thursday of each week. All samples shall be forwarded via air mail immediately after sealing.

(b) Return all sampling flasks in the containers in which they were received, with no additional packing (further packing of these containers in boxes, crates, or other wrapping will not add in any way to the safety of the flasks during shipment and will frequently delay delivery to destination).

3-4. ASSISTANCE FOR EVALUATION AND TREATMENT OF IRRADIATED OR CONTAMINATED PERSONNEL.—Specific guidance for evaluation, monitoring, care and decontamination of irradiated or radioactively contaminated personnel is available in BUMEDINST 6470.10. Advice on the significance of abnormal findings and assistance in the evaluation of exceeding radiation exposure limits to external or internal radiation may be obtained from:

BUMED Code 74, Telephone, Autovon 29-4-4197 or -4224, after working hours Telephone, Autovon 29-4-4348; National Naval Medical Center, Bethesda, Md. 20014; or Naval Hospital, San Diego, Calif. 92134.

Chapter 4

RADIATION PROTECTION STANDARDS

	Article
Responsibility	4-1
Control of Exposure to Radiation	4-2
Radiation Protection Standards for External Exposure	4-3
Radiation Protection Standards for Internal Emitters	4-4

4-1. Responsibility

(1) *Command.* The commanding officer or officer in charge of any activity which possesses or uses radiation sources is responsible for ensuring that measures are established to control ionizing radiation from these sources so that the radiation exposure to individuals under his command or within his jurisdiction will be no greater than the amount prescribed herein. He shall supply appropriate personnel dosimetric devices to, and shall require the proper use of such devices by personnel as defined in article 6-1(1). He shall further ensure that the amount of exposure for each of these individuals is recorded. When it is known that an individual is to perform travel which may involve entry to radiation areas, the activity preparing the travel orders shall include medical and radiation certification and current exposure status. Periodically—at least quarterly—the amount of such exposures shall be furnished to the custodian of the individual's medical record for recording on DD Form 1141 (Record of Occupational Exposure to Ionizing Radiation). He shall provide decontamination clothing and masks and decontamination facilities as necessary for personnel engaged in handling radioactive materials. He shall maintain and operate a monitoring facility to determine and control radiation levels, airborne radioactivity and surface contamination. Records of all such surveys shall be maintained at least for the current year and one subsequent year. Records of surveys indicating significant contaminating events shall be maintained indefinitely. He shall have posted and limit access to Radiation Areas, High Radiation Areas, and Contaminated Areas in accordance with Federal regulations and Navy directives as defined in article 7-3.

(a) The commanding officer or officer in charge of shore installations or activities in which multiple types or quantities of radiation sources are used for research and development, industrial radiography, or medical or dental diagnosis or therapy shall appoint a radiological protection officer to advise on the control of the hazards to health and safety from the specific materials or devices being used.

(b) The commanding officer or officer in charge of an installation or activity licensed by the AEC to use byproduct materials (unless otherwise specifically exempted) shall appoint an ionizing radiation control committee to review proposals for the use of the licensed radiation sources. This committee shall include: (1) the radiological protection officer, (2) the responsible staff medical officer, and (3) other persons as deemed necessary.

(2) *Limitations.* Within the scope of this article:

(a) Major commanders having command jurisdiction over installations and activities using radiation sources shall take such action as is deemed necessary to assure implementation of these regulations and to establish uniform practices and procedures by subordinate commanders.

(b) The Chief, Bureau of Medicine and Surgery shall exercise his assigned responsibilities with respect to safeguarding the health of personnel.

(c) The ionizing radiation control committee shall not perform the functions of a clinical board or committee on radioisotopes in a medical facility, nor the functions of a projects review board in a research facility; nor shall this committee exercise any function in nuclear reactors or weapons programs which are administered under the provisions of other appropriate Bureau instructions.

4-2 Control of Exposure to Radiation

Ionizing radiations are harmful to living cells. The harmful effects occur when radiation ionizes components within these cells. All parts of the body are susceptible to this effect in varying degrees. Blood-forming organs are among the most sensitive. The degree of injury depends primarily upon the amount of radiation energy absorbed by the cell component. Chronic or repeated overexposure will lead to cumulative, permanently harmful effects which develop gradually and insidiously. Except in cases of extreme overexposure, there is a latent period before signs and symptoms of radiation illness appear.

Radiation exposure results from exposure to radiation sources outside the body (External) and from sources deposited in the body (Internal).

(1) *External Radiation Exposure Control.* When the source of ionizing radiation is located outside the body, the following methods of control are applicable:

(a) *Time.* Reducing an individual's working time in a radiation field is the simplest way to limit the exposure. Since the amount of radiation received is equal to the dose rate multiplied by time of exposure, decreasing exposure time results in a proportional decrease in the total dose absorbed.

(b) *Distance.* Radiation intensity varies inversely as the square of the distance from a point source (that is, a source concentrated in a small volume). Therefore, if a worker doubles the distance between himself and the source, his exposure is reduced to one-fourth; increasing the distance three-fold reduces the exposure to one-ninth. Remote handling devices use this principle to reduce exposure.

(c) *Shielding.* Shielding materials absorb a part or all of the energy of different radiations, thus reducing their biological effects. Interposing a shield between the individual and radiation source reduces the amount of radiation received.

(d) *Radioactive Decay.* All radioactive materials decay exponentially at a fixed time rate. The time required for a radioactive substance to decrease to one-half its original activity is called the half-life of that particular substance. Thus, allowing the radioactive material to decay for a period of time will reduce the amount of exposure received when the material is handled.

(2) *Internal Radiation Exposure Control.* Deposition of radioactive material within the body cannot be controlled by time, distance or shielding. If radioactive material is inhaled, ingested, or absorbed through the skin, it may be deposited in various organs or systems of the body. It then acts as a radiation source within the body and will continue to affect the cells of the body until it has been eliminated by natural processes or by radioactive decay. Risk of exposure is greatly reduced by good housekeeping procedures. Containment cleanliness, and appropriate exhaust ventilation are the fundamental principles for reducing the risk from exposure to contaminating materials. Personal protective measures may be accomplished by:

(a) *Avoiding Inhalation.* Personnel shall use the prescribed face mask or respirator whenever the airborne radioactivity levels as referred to in article 1-5(9), are likely to be exceeded.

(b) *Avoid Ingestion.* No edible material of any kind including chewing gum, candy or beverages, nor tobacco or smoking equipment, shall be brought into an area contaminated by radioactivity. Upon leaving a contaminated area personnel should not be permitted to handle any of these materials until they have been carefully monitored and decontaminated as necessary.

(c) *Avoiding Absorption.* Personnel should wear the appropriate anticontamination clothing as prescribed for use in a contaminated area and not allow the outer surface of the gloves or protective clothing to touch the skin. Special care is also re-

quired when removing contaminated gloves and clothing to prevent skin contamination.

(3) *Control Procedures.* Procedures to control exposure to ionizing radiation shall include but not be limited to:

(a) Providing suitable facilities and equipment including handling devices, shields, measuring and monitoring equipment, and personnel protective clothing and equipment appropriate for the operation.

(b) Determining the radiation levels around radiation sources and in work areas.

(c) Establishing radiation areas and limiting access thereto as prescribed in article 1-5.

(d) Providing trained and experienced personnel qualified to use the radiation sources under the conditions of work being done.

(e) Establishing operating procedures which prescribe methods for handling, using, and disposing of sources to minimize the resultant health hazards.

4-3. Radiation Protection Standards for External Exposure

(1) *General.* Every effort shall be made to maintain radiation doses as far below the Radiation Protection Standards as practicable. These standards are consistent with the recommendations of the AEC regulations set forth in Title 10, Code of Federal Regulations, and current BUMED instructions.

(2) *Scope.* The standards prescribed herein are adopted for the control of exposure to ionizing radiation of personnel within the Naval Establishment during peacetime and noncombatant operations, and do not include radiation exposure of an individual incident to medical or dental diagnostic and therapeutic procedures to which that individual is or has been subjected.

(3) *Radiation Protection Standards for Unrestricted Areas.*

(a) Radioactive material and/or other sources of radiation shall not be used, maintained or transferred in such a manner as to cause an individual if continually present in an unrestricted area to receive a radiation exposure in excess of two millirem in any one hour or one hundred millirem in any seven consecutive days.

(b) Higher levels of radiation may be present in spaces accessible to an individual member of the general public provided it can be shown that due to limited occupancy personnel exposures are not likely to exceed 0.5 rem per any period of one calendar year and provided that the anticipated exposure levels are authorized by the Chief, Bureau of Medicine and Surgery

(4) *Radiation Protection Standards for Occupational Exposures.*

(a) *Whole Body Exposure*

(1) Except as provided in paragraph (2) of this section, radioactive material shall not be used in such a manner as to cause any individual in a radiation area to receive in any period of one calendar

quarter a dose in excess of the limits specified in Table II.

(2) An individual in a radiation area may be permitted to receive a dose to the whole body greater than that permitted under paragraph (1) of this section provided:

(a) During any calendar quarter the dose to the whole body from radioactive material and

TABLE II

Rem Per Calendar Quarter

1. Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1.250 rem
2. Hands and forearms; feet and ankles	18.750 rem
3. Skin of whole body	7.500 rem
4. Thyroid	7.500 rem

other sources of radiation shall not exceed 3 rems, and

(b) The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 (N-18) rems where "N" equals the individual's age in years at his last birthday. (Individuals 18 years of age are not permitted to receive a dose to the whole body greater than that permitted under paragraph (1) of this section.)

(b) *Skin Exposure.* In a limited number of operational situations the dose of radiation received may be primarily to the skin of the whole body. For these situations, standards different from those used for whole body and critical organs may be used, provided careful consideration is given to analysis of the exposure environment and the selection of appropriate dosimetry as a basis for evaluating exposure conditions. (See article 4-3(5) below.) Where applicable, the accumulated dose of radiation to the skin of the whole body shall not exceed 7.500 rem in any calendar quarter.

(c) *Extremity Exposure.* In some operational situations the dose of radiation received by individuals may be primarily to the hands and forearms or the feet and ankles. In these situations, standards different from those used for the whole body or critical organs may be used, provided careful consideration is given to the analysis and limitation of exposures as prescribed in article 4-3(4)(a), and 4-3(4)(b). Within these limitations the accumulated dose of radiation to the hands and forearms or the feet and ankles shall not exceed 18.750 rem in any calendar quarter. In determining compliance with this limit the accumulated dose of radiation to the extremities shall include any whole body dose received during other monitoring periods of the calendar quarter.

(5) *Alternate Radiation Protection Standards.* Alternate radiation protection standards other than those prescribed in article 4-3(4) may be used in special circumstances when approved by the Chief,

BUMED. Requests for approval to use alternate protection standards may be made by letter through the proper channels. Proposals for the use of alternate standards should be for clearly defined situations and for a specified length of time. Such proposals should provide complete justification for the use of an alternate standard and should describe the means by which the alternate standard will be implemented and monitored. Simplification of operations, economy, shortening of shutdown time, or similar reasons are not usually considered sufficient reasons in themselves to justify the use of alternate radiation protection standards.

(6) *Members of the General Public and Underage Personnel.* No individual under 18 years of age or member of the general public shall receive in any period of one calendar quarter a dose of ionizing radiation in excess of 10% of the limits specified in Table II.

(7) *Emergency Exposure.* In an emergency it may be necessary for firefighters or other workers to exceed limits prescribed in article 4-3(4) to save life or valuable property. In such situations, the probable effects of high exposure to the rescuer must be weighed against the expected benefits. In emergency situations which require personnel to search for and remove injured personnel or which require entry to prevent conditions that would probably injure numbers of people, the planned dose to the whole body shall not exceed 100.0 rems. In situations where it is desirable to enter a hazardous area to protect facilities, eliminate further escape of effluents, or to control fires, planned whole body dose shall not exceed 25 rems. The above guidance is based on criteria set forth in the National Council of Radiation Protection Report Number 39. When an individual has been exposed to more than 3 rem during the calendar quarter, as a result of such an emergency, he shall be barred from any additional occupational exposure to radiation until he meets the criteria set forth in article 4-3(4) of this manual. Such an exposure shall be reported in accordance with article 5-3(3).

4-4. Radiation Protection Standards for Internal Emitters

(1) *Body Retention of Radionuclides.* Since the human body is selective in retaining radionuclides, general statements cannot be made about the maximum amount of radioactivity which may be retained as internal emitters. The maximum amount of radioactive materials retained in the body (maximum permissible body burden) shall be limited to the amount which results in an exposure not to exceed the biological equivalent of 0.1 microgram of radium-226 in the bones, nor 15 rem per year or 5 rem per calendar quarter for most other individual organs of the body.

(2) *Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure.* The amount of radioactive material retained in the body is limited by controlling the rate of intake of such material. This is accomplished primarily by limiting the average concentration of radioactive materials in the air and water in the occupational

environment. Lists of maximum permissible concentration guides for radionuclides have been published in Table I of Appendix B in Title 10, Part 20 of the Code of Federal Regulations. These limits have been calculated for the age and dose principles set forth in article 4-3(4) based on lifetime occupational exposure of 40 hours per week and 50 weeks per year for 50 years.

(a) During any 7 consecutive-day period, when the number of hours of exposure is more than 40, the specified limits shall be lowered proportionately. For example, if work is for 48 hours the MPC values are 5/6 of those listed in Table 1. When deemed necessary by the commanding officer, the specified maximum concentration of a radionuclide may be exceeded, provided the exposure time during any 7 consecutive days is decreased proportionately from the 40-hour time limit. For example, if work is for 8 hours the MPC values are 5 times those listed in Table II.

(b) Allowance may be made for use of a respiratory device, protective clothing or equipment,

particle size or chemical or physical state of the radionuclide, by the AEC for licensees or by the Chief, BUMED for users of sources which are not licensed by the AEC, otherwise no such allowance can be made. Each application for an exception under this subparagraph shall contain the following information:

(1) A description of the respiratory device or protective equipment to be employed, including the efficiency of the equipment for the material involved;

(2) Procedures for the fitting, maintenance and cleaning of the protective equipment;

(3) Procedures governing the use of the protective equipment, including supervisory procedures and length of time the equipment will be used by the individuals in each work week. The proposed periods for use of the equipment by any individual should not be of such duration as would discourage observance by the individual of the proposed procedures;

(4) The average concentrations present in the areas occupied by employees.

Chapter 5

EXPOSURE RECORDS

	Article
Introduction	5-1
Individual Exposure Record	5-2
Required Reports	5-3
Record Keeping	5-4

5-1. Introduction

All personnel occupational exposures to ionizing radiation must be documented in order to establish individual radiation histories. These histories have both medical and legal significance since they record the amounts of exposure as well as dates and activities at which exposures were received. Additionally, they serve as evidence that occupational exposure limits were or were not exceeded. This Chapter contains the recording and reporting procedures the Bureau of Medicine and Surgery considers necessary and adequate for occupational exposure documentation. Reporting requirements contained herein have been approved by the Chief of Naval Operations. The Radiation Health Officer or Health Record Custodian at each Naval Activity shall be responsible for the documentation of all occupational exposures to ionizing radiation.

BUMED, Code 74, as addressee for annual and situational reports of occupational radiation exposure, serves as the repository of radiation exposure history information for the Navy, and is responsible for the retention and retrieval of all reported data. Radiation Health Officers and Health Record Custodians must ensure the accurate preparation and timely submission of these reports. They must also ensure that individual Health Record entries (on DD Forms 1141) and all supporting records are correct, concise, and in agreement with instructions contained in this Chapter.

Activities with Health Record Custody responsibilities shall maintain a DD 1141 (Record of Occupational Exposure to Ionizing Radiation) for each person occupationally exposed. These activities shall submit the required annual and situational report of personnel exposure to ionizing radiation.

BUMED controlled activities holding AEC licenses will require additional records. These records must include; (1) the AEC license together with its amendments, related correspondence and applicable instructions, (2) listings and authorization relating to Radiation Committee membership and approved users of radioactive material, (3) environmental survey

data, (4) radiac instrument inventories and calibrations, (5) radioactive material receipt, transfer and accountability, and (6) sealed source leak test data.

These records include all the requirements specified in the individual license and the requirements specified in the Code of Federal Regulations, Title 10.

5-2. Individual Exposure Record

The custodian of the individual's medical records shall prepare and maintain for each person occupationally exposed to ionizing radiation a DD Form 1141 (Record of Occupational Exposure to Ionizing Radiation) which is to be completed per instructions below and filed and maintained in the Health Record and in no other location. A computerized printout may be used by those activities possessing Electronic Data Processing equipment. The information on the computerized printout is to be updated at least once a quarter and the information entered on the form is to be prepared in the same sequence as it appears on the DD Form 1141 and will include all the information that is required on the DD Form 1141. This computerized printout is to be filed at least annually in the individual's medical record. A random sampling of the computerized printout shall be cross-checked against the record system or EDP records referred to in paragraph 5-4(1) of this Chapter. This crosscheck shall be performed semiannually on 1 per cent of the total computerized printouts to ascertain the accuracy of the recordings. If errors are found, a larger per cent of the records should be checked. The crosscheck shall be noted by dating, signature and verification of the accuracy of the computerized printout. For activities holding AEC licenses, the DD Form 1141 shall be used in lieu of AEC Form 4 (Occupational External Radiation History) and AEC Form 5 (Current Occupational External Radiation Exposure). A copy of DD Form 1141 is included in appendix A.

(1) *Initial Determination.* In the initial preparation of the DD Form 1141, reasonable effort should be made to obtain complete reports of all previous exposures based upon recorded personnel dosimetry.

This shall be accomplished by correspondence with previous commands, employers and/or BUMED Code 74.

(a) For each period in which the individual was engaged in activities where occupational exposure to ionizing radiation was probable and no record or only an incomplete record of the exposure during the period can be obtained, it shall be assumed that an occupational exposure of 3.75 rem per calendar quarter occurred and this dose estimate shall be assigned for unknown radiation exposure obtained prior to 1 January 1961 and 1.25 rem per calendar quarter assigned for each quarter exposed after 1 January 1961. Educated estimates of radiation exposure should be obtained in accordance with paragraph 5-2(1)(d) prior to assigning the aforementioned values. In cases where the nature of the radiation is unknown, it shall be assumed to be gamma radiation. Where the maximum permissible lifetime exposure (Column 14 of the DD 1141) is exceeded, the results shall be forwarded by letter, with a copy of the DD 1141 or EDP printout to the Bureau of Medicine and Surgery, Code 74, for evaluation.

(b) When an individual was potentially exposed at more than one facility, the cumulative exposure shall be calculated and recorded in items 7 through 12, as appropriate. The sum of assigned or unknown exposures stipulated in the previous paragraph, shall be entered on the DD 1141, denoted by asterisks or footnotes, and explained in the remarks section of the DD 1141. This explanation shall be transcribed to the NAVMED 6470-1 upon submission of the Annual or Situational Report of Personnel Exposures to Ionizing Radiation, Report Symbol 6470-3 and as a footnote on the computerized Report of Personnel Exposure to Ionizing Radiation, Report Symbol 6470-3.

(c) If an individual has been occupationally exposed at any activity possessing an Atomic Energy Commission Byproduct Material License, and his exposures have been recorded on AEC-4 and AEC-5, the cumulative exposure obtained from these forms shall be recorded on the DD 1141 in item 7 through 14, as appropriate, and a statement regarding the source of that information shall be entered in item 16 of the DD 1141.

(d) When a film badge or dosimetric device is lost, damaged or destroyed the Medical Officer or Radiological Health Officer as applicable, shall be notified and exposures shall be estimated based on:

(1) Exposure times and radiation levels.

(2) Exposures of other personnel performing similar work.

(3) Pocket dosimeter indications if available. The exposure estimate and the basis for this estimate shall be recorded and approved in writing by the Medical Officer and/or Radiation Health Officer. For commands not having a medical officer or a radiation health officer, these entries shall be approved by the Medical Department Representative and Executive Officer and reviewed by the cognizant medical officer. Reports of lost, damaged, or destroyed film badges should *not* be entered in the

Medical Record. When submitting the Annual or Situational Reports, transcribe the exposure information in accordance with instructions in paragraph 5-2(1)(b).

(e) If information for items 7 through 13 was acquired from a previous DD Form 1141, all previous copies of this form shall be retained in the individual's medical records.

(f) An annual verification of the accumulated dose (Column 13) is recommended, preferably by use of an adding machine.

(g) If erroneous entries have been made to the DD 1141, corrections or additions shall conform to the stated requirements of the Manual of the Medical Department, paragraph 16-18(7), which states if an erroneous entry is made in a "Health Record, it shall not be stricken out. An additional entry shall be made showing wherein and to what extent the original entry is erroneous."

(2) *Current Record.* Appropriate entries on each individual's DD Form 1141 shall be made periodically, at least quarterly, from the exposure records supplied under the provisions of article 4-1 of this manual. These entries are to be completed per instructions on the back of the form. For individuals who are exposed to radiation to the extremities, as defined in articles 4-3(2)(b) and 4-3(2)(c), as well as whole body exposure, separate DD Forms 1141 shall be maintained to record each type of exposure, with appropriate description under item 16 of the form.

(a) When an individual is occupationally exposed to ionizing radiation at a naval installation or activity, other than where his medical records are maintained, the Commanding Officer, or Officer in Charge of that installation or activity shall ensure that exposure data required for entry on DD Forms 1141 is furnished to the custodian of the individual's records for entry and inclusion in the Annual or Situational Reports MED 6470-1 or MED 6470-3, in accordance with article 5-3 of this manual. This exposure data shall be forwarded to the record custodian within 30 days of the departure of the individual. Exposures received by visiting or temporary duty personnel whose exposures are not reported annually by their parent activities, shall be submitted on a Situational Report, MED 6470-1 or MED 6470-3.

(b) When an individual is exposed to ionizing radiation at an installation outside the jurisdiction of the Department of the Navy, he shall ensure that the exposure data is furnished to the custodian of his medical record for entry on the DD 1141, and submission on the Annual or Situational Reports, MED 6470-1 or MED 6470-3, in accordance with article 5-3 of this manual.

(c) *Internal Contamination.* Results of all internal contamination measurements shall be recorded in the remarks section of the individual's DD 1141, Record of Exposure to Ionizing Radiation, and reported annually in the remarks section of the NAVMED 6470/1, Personnel Exposure to Ionizing Radiation, Report Symbol MED 6470-1. The results shall include the following information: isotope moni-

tored, microcuries or nanocuries present, and the anatomical location of isotope. A Form covering this information may be marked as "Addendum to DD 1141" and incorporated with the DD 1141 in the health record. Activities that have electronic data processing capabilities and normally submit EAM type reports under Report Symbol MED 6470-3 will submit results of internal contamination in the "Remarks" section of NAVMED 6470/1 Report Symbol MED 6470-1 or incorporate the above required information in the "Remarks" section of the NAVMED 6470/3 Report Symbol MED 6470-3. This type of submission shall not conflict with the format requirements of paragraph 5-3(6).

(d) *External Contamination.* Results of all cases of external contamination measurements in excess of 450 micromicrocuries of beta or gamma emitting contamination, or in excess of 50 micromicrocuries of alpha emitting contamination, shall be recorded in the remarks section of the individual's DD 1141, Record of Exposure to Ionizing Radiation, and reported annually in the remarks section of the NAVMED 6470/1, Personnel Exposure to Ionizing Radiation, Report Symbol MED 6470-1. The results shall include the following minimal information: isotope monitored, microcuries or nanocuries present, and the anatomical location of contamination. A Form covering this information may be marked as "Addendum to DD 1141" and incorporated with the DD 1141 in the health record. Activities that have electronic data processing capabilities and normally submit EAM type reports under Report Symbol MED 6470-3 will submit results of external contamination in the "Remarks" section of NAVMED 6470/1 Report Symbol MED 6470-1 or incorporate the above required information in the "Remarks" section of the NAVMED 6470/3 Report Symbol MED 6470-3. This type of submission shall not conflict with the format requirements of paragraph 5-3(6).

(e) The Medical Officer, Radiological Health Officer or Health Record Custodian shall ensure that the exposure data resulting from these exposures is obtained and properly recorded on DD 1141. This entry should identify the installation where exposure was received and the dates of the exposure.

(3) *Retention Disposition and Release of Information.*

(a) DD Form 1141 is a permanent component of the individual's medical records and should be safeguarded as such; however, commanding officers, authorized inspecting officials, supervisors of persons occupationally exposed to ionizing radiation or individuals concerned may review DD 1141 with the custodian of the medical records. The medical record custodian may exchange exposure data with installations outside the jurisdiction of the Department of the Navy for any persons occupationally exposed at the installation upon written request, provided a release authorization signed by the exposed individuals is forwarded with the request.

(b) When a civilian employee is not included in a Federal civilian employees health service, DD

Form 1141 or the computerized print out shall be maintained as a permanent document in his official personnel folder.

(c) If a service member is released or retired from active duty or if a civilian employee terminates employment, he shall be provided with a statement of his total external occupational radiation exposure received during his period of employment or service with the United States Navy. Copies of the statement shall be forwarded to the Director of Regulations, United States Atomic Energy Commission, Washington, D. C. 20545 and to the Chief, Bureau of Medicine and Surgery, Code 74. The statement shall include the following information:

(1) Identification and employment information

(a) The statement "This statement is submitted in accordance with paragraph 5-2(3)(c) of NAVMED P-5055, Radiation Health Protection Manual" shall be included on the form or letter provided to the individual.

(b) Name, social security number and date of birth of the terminated individual.

(c) Dates of employment (day, month, year) and identification of the activity at which the exposure was incurred.

(2) Exposure information

(a) Total cumulative occupational exposure received by the individual during his term of employment or service with the United States Navy.

(b) Source of Radiation Involved (X-ray, gamma, beta or neutron).

(c) Part of body exposed (whole body, skin of whole body or extremities).

The statement shall apprise the employee of the significance of the occupational exposure received by insertion of the following statement on the report: "Your permissible life-time whole body dose calculated in accordance with universally accepted standards (maximum permissible dose = $5(N-18)$) is _____ rem."

(d) DD Form 1141 shall be permanently retained in the retired medical records of a service member who has been occupationally exposed to ionizing radiation during his service. Military personnel who are transferred, shall have their DD 1141 accompany them and a statement of exposures not recorded as of the date of transfer shall be forwarded to their next duty station within 45 days. Data for MED 6470-1 or MED 6470-3 shall be obtained from the records or a similar system required by article 5-4(1). Disposition of DD Form 1141 for retired or separated civilian personnel shall be made in accordance with governing civilian personnel directives.

(e) Copies of Annual Reports, MED 6470-1 or MED 6470-3, Personnel Exposure to Ionizing Radiation, and the Situational Reports, MED 6470-1 or MED 6470-3 should be retained indefinitely.

(4) *Report on Industrial Radiographers to the AEC.* Reports shall be submitted to the AEC in accordance with the Code of Federal Regulations, Title 10, Part 20, paragraphs 20.407 and 20.408. Radiation histories shall be submitted by copying

applicable DD 1141's. Numbers of personnel badged or exposed shall be submitted by letter.

5-3. Required Reports

(1) *Annual Reports, MED 6470-1 or MED 6470-3.* The medical department representative or the custodian of the health records of individuals attached to any installation, activity, ship or unit at which personnel are occupationally exposed to sources of ionizing radiation, shall submit NAVMED 6470-1, Personnel Exposure to Ionizing Radiation, MED 6470-1 or 6470-3 in punch card format annually to BUMED, Code 74, by 31 January. This report shall include those personnel on board 31 December who have been or are being occupationally exposed to ionizing radiation and those personnel on board 31 December who have been or are being occupationally exposed to ionizing radiation during temporary assignments to a facility not under naval jurisdiction. Film badge readings of 00.000 rem are required to be recorded.

(2) *Situational Reports, MED 6470-1 or MED 6470-3.*

(a) If an exposed individual is transferred, retired or terminates employment, MED 6470-1 submitted on NAVMED 6470-1 or MED 6470-3 in punch card format, shall be prepared and forwarded to BUMED, Code 74, by the individual's activity, within six weeks of such transfer, retirement, or termination of employment.

(b) If a visitor at a naval facility or an individual on temporary duty from an activity which does not submit annual or situational reports, receives an exposure, a situational report MED 6470-1 submitted on NAVMED 6470/1 or MED 6470-3 in punch card format, shall be prepared and forwarded to BUMED, Code 74, by the activity at which the exposure was incurred within six weeks of the individual's departure from the activity.

(3) *Report of Personnel Exceeding Radiation Exposure Limits, MED 6470-2.* This report shall be submitted to BUMED, Code 74, as follows:

(a) If personnel have received a whole body dose of more than 3 rem in any calendar quarter, this report shall be forwarded on NAVMED 6470/1 within 30 days from the determination of such exposure.

(b) If personnel have received a whole body dose of more than 5 rem in a single incident, this report shall be forwarded on NAVMED 6470/1 within 24 hours from the determination of such exposure.

(c) If any individual has received a whole body dose of more than 25 rem in a single incident, BUMED, Code 74, shall be notified immediately by priority message. During "MINIMIZE," Electrical Transmission is authorized. In addition, a detailed NAVMED 6470/1, furnishing all information available on the overexposure, the reason for such overexposure, the general status of health and physical condition of the individual, and a summary of treatment rendered or recommended, shall be furnished to BUMED, Code 74, at the earliest practicable date following the incident. In any event, this amplifying

report must be submitted within 15 days after exposure. This report shall be completed as per instructions in article 5-3(5) of this manual. A copy of NAVMED 6470/1 is included in appendix A.

(4) *Radiation Incident Report, Report Symbol MED 6470-9 (MIN:ETAUTH).*

(a) Any radiation incident such as loss of radioactive material or release of radioactive material to the environment that is likely to endanger personnel shall be immediately reported to BUMED, Code 74, by message with the Radiation Safety Department, National Naval Medical Center, Bethesda, Maryland an information addressee. Transmission during periods of "MINIMIZE" is authorized; reference OP-NAVINST 5214.3 series. The Code of Federal Regulations, Title 10, Part 20 sets the criteria for the release of radioactive material to the environment.

(5) *INSTRUCTIONS for Completion of NAVMED 6470/1 Report of Exposure to Ionizing Radiation.*

(a) In the heading of the form, check the two appropriate boxes to indicate, 1) whether the report is an Annual Report or a Situational Report and, 2) whether it is a Report of Personnel Exposure to Ionizing Radiation, MED 6470-1 or a Report of Personnel Exceeding Radiation Exposure Limits, MED 6470-2.

(b) Items 2 through 17.

- 1 Enter name and address of reporting activity.
- 2 Enter Reporting Facility Code. The reporting facility code is devised as listed in Articles (6) (3) (a) and (6) (3) (b) of paragraph 5-3 of this manual.
- 3 Enter calendar year reported.
- 4 Enter date reported.
- 5 Enter name as currently carried on rolls—last name, first name and middle initial, as appropriate. If this combination exceeds 19 spaces, enter last name and initials only.
- 6 Enter individual's Social Security Account Number.
- 7 Enter individual's year and month of birth. Enter last two digits of the year; enter month in 2 digits using the appropriate code from the series 01 through 12.
- 8 Enter year, month and day exposure was considered to have started, i.e., 70-01-01.
- 9 Enter year, month and day exposure was considered to have ended, i.e., 70-12-31.
- 10 through 14 Enter radiation doses received to three decimal places, i.e., 03.450. Enter doses evaluated as "zero" as 00.000. Do not use "X's" or term "minimal."
- 11 Enter X-ray and Gamma dose in rem.
- 12 Enter Neutron dose in rem.
- 13 Enter accumulated dose for this period; sum of items 11 and 12. This

entry should normally be only for the current calendar year. Previous year's exposure should have already been reported on prior annual reports.

- 14 Enter Total Lifetime accumulated dose in rem.

15, 16, 17 Self Explanatory.

(6) *Preparation of MED 6470-3, Personnel Exposure to Ionizing Radiation.* Those activities having electronic data processing equipment may use punch cards and tabulated reports in lieu of NAVMED 6470/1. The format of the report, Personnel Exposure to Ionizing Radiation, is assigned Report Symbol MED 6470-3. IBM 5081 or other similar type stock card form shall be used. Punch cards shall be submitted in alphabetical order. All information on the tabulated report shall be printed in the same sequence in which it appears in the punched cards. The punch cards and the tabulated listing containing the name and address of the activity shall be prepared as follows and submitted annually to BUMED, Code 74, by 31 January, and situationally as required:

Field

- 1 *Card Code Punch 20 in card columns 1 and 2.*
- 2 *Leave card column 3 blank.*
- 3 *Reporting Facility Code.* Punch facility code number in card columns 4 through 9 to identify the reporting facility. This code is devised as follows, for all ships and stations having medical department personnel.
 - (a) *First Digit.* The first digit of the facility code shall be assigned to identify the type of reporting facility as follows:
 - 0 Naval Hospitals and Hospital Ships
 - 2 Dispensaries with Authorized Operating Beds
 - 3 Naval Dispensaries
 - 4 Other Dispensaries and Shore Activities Medical Departments in Mobile Activities
 - 5 Ships (except MSTs ships)
 - 6 Ships, MSTs
 - 7 Marine Corps FMF Units
 - 8 Construction Battalions
 - 9 Other Mobile Units
 - (b) *Last Five Digits.* The last five digits of the facility code shall be assigned the same as the Unit Identifier Code (UIC) listed in the Navy Comptroller Manual, Volume 2, Chapter 5. If the Unit Identifier Code number is less than five digits, precede the number with zeros.
- 4 *Name.* Punch name as currently carried on the rolls—last name, first name, middle initial as appropriate—in card columns 10 through 28. Limit to 19 columns by using last name and initials, if necessary.
- 5 *Social Security Number.* Punch individual's social security number in card columns 29 through 37. For foreign military personnel punch FM (for foreign military) in card columns 29 and 30, followed in card columns 31 through 37 by the individual's service number. If service number contains more than 7 digits, use the last 7 digits of the number; if less than 7 leave unused card columns to the right blank. For foreign civilian employees punch FC (for foreign civilian) in card columns 29 and 30, followed by employee pay number starting in card column 31. Leave blank any unused card columns to the right in the 9-digit field.
- 6 *Birth, year and month.* Punch individual's year of birth in card columns 38 and 39. Punch month of birth in card columns 40 and 41. Use 01-09 for January-September and 10, 11 and 12 for October through December, respectively.
- 7 *Age.* Punch individual's age in card columns 42 and 43.
- 8 *Exposure Date.* Punch year, month and day on which exposure began as follows: year in card columns 44 and 45; month in card columns 46 and 47; day in columns 48 and 49. In the same order and manner, punch year, month and day exposure ended in card columns 50 through 55. Use 01-09 for months and days so identified that have less than 2 digits.
- 9 *Skin Dose.* (Formerly identified as Beta dose). Punch skin dose as determined from film badge, in rem, in card columns 56 through 60.
- 10 *X-ray and Gamma Dose.* Punch combined gamma and x-ray dose, as determined by the appropriate dosimetric devices, in rem, in card columns 61 through 65.
- 11 *Neutron Dose.* Punch neutron dose, as determined by the appropriate dosimetric device, in rem (using the appropriate QF for calculations) in card columns 66 through 70.
- 12 *Total Dose This Period.* Punch the total of field 10 (x-ray and gamma dose), and field 11 (neutron dose) for this reporting period in card columns 71 through 75.
- 13 *Total Lifetime Dose.* Add the total dose this period (field 12) to the previous total lifetime dose (item 13, DD 1141) and punch the sum in card columns 76 through 80. Punch all radiation doses to three decimal places. Film badge readings of 00.000 are required. These are equally as important as positive readings for medico-legal purposes.

5-4. Record Keeping

(1) *Working copy of NAVMED 6470/1.* To maintain accurate DD 1141's and submit accurate NAVMED 6470/1's a reliable record system is essential. It is suggested that each activity's record system contain a working copy of NAVMED 6470/1 on which is transcribed all required data from the DD 1141 on any persons transferred during the month. For activities which have electronic data processing equipment, EDP records are satisfactory. This data shall be updated when the film badge is processed and used to prepare the Situational Report (NAVMED 6470/1). The working copy of the NAVMED 6470/1 may be destroyed when the required situational report is submitted. A file copy of the situational reports must be maintained indefinitely.

(2) *Film Log.* A log containing the film number, name, date, time of issue and return, and type of radiation is suggested for all activities utilizing film badges.

(3) *Film File.* The film file shall be maintained by filing film in the most expeditious manner in which retrieval and identification is possible. A suggested practical method of maintaining a film file is to stack the film, including controls, from one processing period in numerical order, secure with a rubber band and place in a suitable box or envelope for storage. This container is to be identified as to the activity and processing period. For ease of retrieval, storage containers should be maintained in chronological order. Processed film and associated photodosimetry work sheets shall be retained for the current year and one subsequent year after which they shall be discarded.

Chapter 6

PERSONNEL DOSIMETRY

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6-1. RESPONSIBILITIES

Personnel dosimetry is a technique for detecting and measuring an individual's exposure to ionizing radiation. The Bureau of Medicine and Surgery requires appropriate naval activities to maintain a dosimetry program for personnel who may be occupationally exposed to ionizing radiation. Personnel dosimetry is practiced in order to document an individual's exposure, to determine if an individual has exceeded radiation exposure limits, and to aid in minimizing exposure. Personnel dosimetry has both medical and legal significance and must be conscientiously practiced by trained personnel under competent supervision.

(1) *Command Responsibility.*—The commanding officer of any activity where occupational radiation exposures are incurred shall insure that appropriate personnel dosimetric devices are supplied and shall require the use of such devices; (1) by all personnel who are likely to exceed 300 mrem per calendar quarter, (2) by all personnel entering a high radiation area (i.e., an area where exposure rate is greater than 100 mrem/hour), and (3) by all other personnel as deemed necessary. The type of dosimetric device or devices used shall be specified by the commanding officer, except that all radiographers and radiographers' assistants, as defined in Title 10, Part 34 of the Code of Federal Regulations, shall wear both a film badge and a self-indicating dosimeter. Commanding officers shall be guided by applicable instructions stipulating the choice of dosimetric devices issued by various naval commands.

(2) *Individual Responsibility.*—When a personnel dosimetric device is required, it shall be worn at all times in any area where a radiation exposure may occur. The individual is responsible for loss of, or

damage to such a device while in his possession. At the end of the working period, the dosimetric device shall be placed in a low background area.

6-2. DOSIMETRIC DEVICES

Acceptable dosimetric devices include; (1) film badges, (2) pocket dosimeters, (3) wrist badges and film rings, (4) luminescent dosimeters, and (5) accident dosimeters.

(1) *Film Badges.*—Film packets contain one or more photographic emulsions with varying degrees of sensitivity to beta particles, gamma rays, and x-rays, or to fast and thermal neutrons. Film packets are placed in the standard Navy stainless steel film badge holders, which are designed to differentiate between these radiations. Film badge holders are provided with a clip or other suitable means for attachment to the individual's clothing.

(a) *Normal Use.* The film badge shall be worn on the front surface of the head or trunk of the body, in the area expected to receive the highest exposure. When the location of maximum exposure to the body is not certain, additional dosimeters and/or film badges shall be worn. The film badge shall be worn on the outer garments, except where contamination of the badge could occur, or in difficult working conditions where the film badge might be lost or damaged. In such cases, the film badges should be worn under protective clothing. The wearer is responsible for his badge and the contained film and should take care to avoid its exposure to excessive heat, humidity, or moisture. Writing on any portion of the film packet other than in the narrow area above the serial number (front or back) should be avoided due to the pressure sensitive nature of the film emulsion.

(b) *Additional Use.* The film badge may be used as a means of identification for security purposes, provided the security program does not conflict with the photodosimetry program. Numbering or other identification may be placed on the clip, on the edge of the badge, or on the steel strip between the open window and cadmium shield. Any additional alteration of the film badge must be approved by BUMED, Code 74.

(2) *Pocket Dosimeters.*—Pocket Dosimeters are pencil-shaped ionization chambers calibrated to measure total exposure to gamma radiation. They are available in ranges from 0-200 mrem to 0-600 rem.

(a) *Use.* Pocket Dosimeters should be used in addition to film badges when higher levels of radiation may be encountered or when frequent exposure estimates are required. When used in addition to the film badge, the pocket dosimeter shall be worn in close proximity to the film badge. The choice of range and number of pocket dosimeters shall be made by the Radiation Control Officer or the Radiation Health Officer.

(b) *Reliability Tests.* Pocket Dosimeters must be tested for both drift and accuracy. These tests will be performed in accordance with NAVELEX, Standard Maintenance and Calibration Procedures for Dosimeters, Procedure number 3.C. Tests must be performed: (1) at least semi-annually, unless otherwise specified by applicable instructions, (2) whenever new dosimeters are put into use, (3) whenever the dosimeter has been dropped or mishandled, and (4) whenever dosimeter measurements appear to be in error by more than $\pm 15\%$.

(3) *Wrist Badges and Film Rings.*—For certain special situations, the wearing of wrist badges or film rings to measure radiation exposure to the forearms and hands may be required. These devices may be procured commercially or fabricated locally. Great care must be exercised in the interpretation of results.

(4) *Luminescent Dosimeters.*—The group includes both photoluminescent and thermoluminescent devices. The DT-60D/PD, which the Navy issues for NBC warfare defense purposes is a silver phosphate photoluminescent-type dosimeter. The DT-60-D/PD will detect up to 600 rem of gamma radiation, provide an estimate of integrated dose over a long period of time, provide a permanent record of exposure, and is reusable. Thermoluminescent dosimeter systems are capable of detecting exposures in the range of 1 millirem to 10^5 rem, give estimates of integrated doses over long periods, are reusable, have an indefinite shelf life and have very little energy dependence. The systems presently available require that the dose be interpreted by heating the thermoluminescent material to the proper temperature and interpreting the resulting signal into a dose. There is no permanent record of dose as the dose received is erased with each reading. Two commonly used thermoluminescent materials are Lithium Fluoride (such as used in the TLD 700 powder of the accident dosimeter system) and Calcium Fluoride.

(5) *Accident Dosimeters.*—Accident dosimeters contain a number of neutron activation foils together

with a high-range gamma thermoluminescent dosimeter. Most of these systems are capable of measuring neutron and gamma exposures up to 50,000 rem. Accident dosimeters are a supplement to the other dosimetric devices and can be built in or attached to a film badge. The purpose of accident dosimeters is to measure high exposures beyond the normal range of dosimetric film. The accident dosimeter is available to selected activities as the DT-518/PD.

6-3. PHOTODOSIMETRY AT NAVAL ACTIVITIES

The Medical Department at each naval activity where military or civilian personnel are exposed to ionizing radiation shall maintain a Radiation Health Protection Program. Unless other types of dosimetry are approved by BUMED, the dosimetry program shall be based on photodosimetry and its establishment shall be a responsibility of the senior medical representative present. Film processing, exposure evaluation, and exposure documentation are Medical Department functions to be supervised by the Radiation Health Officer or his assigned equivalent. In all cases, the photodosimetry program will be adequate to meet the requirements of paragraph 6-1(1).

(1) *Major Processing Activities.*—Major dosimetric activities are shipyards engaged in nuclear ship construction or upkeep and Naval Research Laboratories utilizing radiation producing equipment or source materials. Organizations so designated shall include on their radiation protection staff, persons well trained in all aspects of dosimetry used. They shall have processing equipment, measuring devices, and calibration sources appropriate to the execution of a complete high quality personnel monitoring program.

(2) *Special Processing Activities.*—These activities have particular requirements determined by BUMED and include nuclear-powered ships and their tenders, submarine base, and repair activities. Such commands may deal with high radiation intensities and may require immediate evaluations of personnel exposure. Therefore, trained technicians and/or supervisors along with necessary equipment are required, and shall be provided to evaluate up to a few hundred dosimetric devices per month. Additional technical assistance will be provided these activities by BUMED, Code 7421.

(3) *Non-processing Activities.*—Many naval facilities requiring a photodosimetry program will not be categorized as either a major or special processing activity. Such activities utilize a comparatively small number of film badges per month and will have little need for on-the-spot exposure evaluations. These activities shall, nevertheless, maintain a Radiation Protection Program. The dosimetry program must be adequate to provide the issuing of dosimetric devices and the recording and reporting of occupational exposures.

(4) *Film Processing Centers.*—In the course of administering the Navy's Dosimetry Program, BUMED

has observed that cost reductions in equipment, manpower, and related training, as well as greater accuracy in exposure evaluation, can be achieved by keeping the number of major and special processing activities to a practical minimum. To this end, one or more Film Processing Centers will be maintained under BUMED management control. Such a center shall function to give film processing services to non-processing activities as well as to serve the Navy's dosimetry program in aspects of research and technology. Requests for film processing services or other dosimetry information shall be made to BUMED, Code 7421, in accordance with BUMED Instruction 6470.8 series. Currently, the Radiation Safety Department, National Naval Medical Center, Bethesda, Maryland 20014, is designated as a film processing center and will promulgate film submission requirements.

6-4. PHOTODOSIMETRY PROGRAM

(1) *General Requirements.*—Photodosimetry is an evaluating technique which utilizes photographic emulsions sensitive to ionizing radiation to determine an individual's exposure. Radiation passing through a grain of silver halide in the emulsion causes a change, resulting in the conversion of the grain to free silver when the film is developed. The silver causes a blackening of the emulsion which is measured as an increase in the optical density or as a darkened track of adjoining granules. With proper calibration, this darkening can be related to radiation exposure.

(a) *Factors.* To obtain accurate results, it is necessary to be consistent in all photodosimetric procedures. Among the many factors which affect film density are (1) emulsion type, (2) background density or base fog of the film, (3) type of film badge utilized, (4) type, concentration, age, and temperature of the developing solution, (5) development time, (6) amount of agitation during development, (7) fixing time, (8) accuracy of the densitometer, and (9) operator error.

(b) *Density.* To relate density to exposure, it is necessary to use a film calibration curve specifically developed for the type of film and radiation in question. Film calibration curves such as shown in Appendix C for interpreting Kodak Type 3 film may be requested from BUMED, Code 7421. Other variables must be controlled as follows:

1. Emulsion control and exposed film must be from the same emulsion batch and whenever possible, from the same package.

2. Emulsion control film shall be used to subtract base fog in order to obtain a net density for evaluation.

3. Emulsion control film shall be kept in an environment where temperature and humidity factors are similar to those where films are being worn or exposed. Control film must not be exposed to radiation above natural background levels.

4. Kodak Type 3 film is extremely sensitive to X and gamma radiation. A gamma radiation exposure of 4 mrem produces a detectable increase in density. This film must not be stocked or stored near

sources of radiation unless adequate shielding is provided.

5. All photographic film is subject to fogging by certain chemical vapors such as mercury, ammonia, or sulfur. Storage in areas where these vapors may exist must be avoided, especially after the stock package has been opened and the vapor seal broken.

6. Unopened packages of stock film should be stored at 35 to 50 degrees F. Opened packages should be stored at room temperature and humidity. Temperatures above 70 degrees F and humidity above 50% should be avoided wherever possible. If opened packages are returned to cold storage, the vapor seal must be secured to prevent the forming of condensation when the cold film packets are again removed from the cold storage. Wrapping in plastic alone is not adequate to secure the vapor seal.

7. The variation of film response with photon energy complicates the proper evaluation of exposure to energies below 0.2 MeV. For X and gamma rays of 0.2 MeV to 3 MeV, the film response is essentially constant. Below this range the variable response may require special evaluation (energy correction curves), except in a limited range of diagnostic x-ray energies for which calibration curves are provided by BUMED, Code 7421 (See Appendix C).

8. Prior to issue of new film, one film from each end and from the central portion of each package shall be processed to ensure that base fog of the fast component is within the normal range. The normal range is considered to be approximately 0.3 density units for fresh film and not over 0.6 density units for film approaching its expiration date. Due to its sensitivity, the initial base fog of Kodak Type 3 film will seldom be less than 0.28 density units for fresh film.

9. Emulsion control film, quality assurance film, and issued films should be processed together to eliminate the effects of processing variations.

10. Processing solutions will not be used to exhaustion.

11. A film should be processed to be certain that base fog is within the normal range whenever solutions are prepared.

6-5. STANDARD PHOTODOSIMETRY EQUIPMENT

(1) *Photographic Emulsions*

(a) *Film Description and Availability.* Film Radiac Pack, FSN 6665-935-4327, Kodak Type 3, shall be used for detecting beta, gamma, and thermal neutron radiation. Type 3 film is available from the following distribution points: (1) NSB, New London; (2) NSC, Norfolk; (3) NSC, Charleston; (4) NSC, Oakland; (5) NSC, Long Beach; (6) NSC, San Diego; (7) NSC, Pearl Harbor; (8) NSC, Puget Sound.

Each film packet contains two component films; fast or "sensitive", and slow or "insensitive." In the film packet, the fast film is always in front of the slow film. The front of each packet is marked with a prefix letter followed by a 5-digit serial number for identification. This number appears on both films within the packet.

Film Radiac pack, neutron monitoring (Kodak, Type A) FSN 6665-176-5112 is available from the same distribution points as Type 3 film, and must be included in the film badge for personnel likely to receive neutron exposures. The front of the packet is marked with a prefix letter followed by a 5-digit serial identification number. The number appears on the film within the packet.

(b) *Sensitivity.* In general, film sensitivity varies with the type and energy of exposure. However, this occurs almost entirely at energies below 0.2 MeV. For example, an exposure 0.020 rem of hard gamma produces only 0.05 density units on Type 3 film; while a similar exposure to lightly filtered 80 kVp diagnostic x-ray (approx. 30 KeV effective) results in a density of 1.2. Thus, the Type 3 film is about 14 times more sensitive to low energy x-rays. The high sensitivity peak varies only slightly for lightly filtered x-ray energies in the range of 60 kVp to 120 kVp. Therefore, a standard calibration curve may be used for most exposures from diagnostic equipment. Correction factors for effective energies above and below this range are available from BUMED, Code 7421.

(c) *Film Range to Beta-Gamma.* For beta-gamma radiation, the combined exposure of the fast and slow Kodak Type 3 film is from 0.004 rem to 150 rem (density 3.0 on slow component), 450 rem (density 4.0 on slow component), or 1000 rem (density 4.6 on slow component). The fast component is limited to exposures less than 2 rem. For gamma exposure exceeding the range of Type 3 film, evaluations will be made from the thermoluminescent element of the accident dosimeter, DT-518/PD (Range up to 50,000 rem). NOTE: Accident dosimeters will be provided only in special cases, such as for personnel working around reactor fuel or operative reactor plants.

(d) *Film Range to X-ray.* Because of its high sensitivity to diagnostic x-rays, the combined exposure range of the fast and slow Type 3 film is from 0.001 rem to 20.0 rem (density 4.0 open window area). The range of the fast film for the open window area is limited to 0.08 rem (density 4.0). To evaluate higher exposures on the fast film, density vs exposure curves are also plotted for metallic filter areas of different densities, i.e., Single Steel, Double Steel, and Cadmium. This family of curves serves two purposes: (1) They extend the range of the fast film to 10.0 rem (Cd density 1.5); (2) They provide confirmation that the film exposure is in the energy range of the calibration curve. This is confirmed by observing the densities found in two or more filtered areas (or open window and one filter area) and should indicate approximately the same exposure when applied to the appropriate curve.

(2) *Film Badge Holders.*—The film packets are placed in film badge holders having various absorbers of different densities to differentiate between energies and type of ionizing radiations. The holder, Radiac Detecting Element FSN 6665-299-9825, is the standard item of issue and will be used in all cases unless prior approval is granted by BUMED, Code 74. This

holder is constructed of stainless steel and provides five areas for density measurements: (1) "open window", (2) cadmium, (3) single steel, (4) double steel, and (5) cadmium plus single steel. Figure 1 illustrates the different areas of the badge. The holder comes equipped with a clip for fastening to an outer garment of the person being monitored. Any modification of this holder, other than modifications promulgated by instructions or notices or the adoption of different film badge, must have prior approval of BUMED, Code 74. As an exception, belt loops which enable the badge to be worn on the belt may be installed on the back side without prior approval. Removal of the spring clip must be approved by BUMED, Code 74. Type 3 film packets shall be placed in the film badge holders so that the letter designator preceding the serial number lies forward and at the open window end. If unnumbered neutron film is used, it shall be placed behind the Type 3 film packet with the opening tab to the right and at the shielded end. Numbered neutron film shall be oriented with the letter designator at the open window end. If neutron film is not used, either a back-up Type 3 film packet or neutron film packet must be placed behind the front film packet. The back-up film should be given a distinctive mark and left in the badge for reuse. Back-up film is necessary in all cases. Without neutron or Type 3 "back-up" film, exposure to energies above 0.660 MeV will appear 15% to 20% high. This is a result of unattenuated back-scatter from the rear cadmium shield.

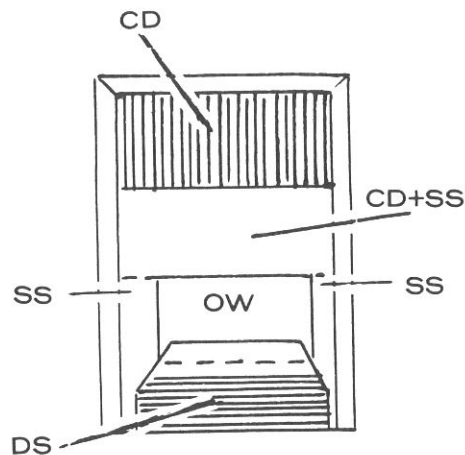


Fig. 1. Film Badge showing different areas where film densities may be measured.

(3) *Densitometer.*—The densitometer is used to measure optical densities of dosimetric film. The density of the photographic emulsion; that is, the relative degree of darkening of the exposed and processed film, bears a definite relationship to the type of ionizing radiation and the amount of exposure.

(a) *Densitometers.* The MACBETH GN-304 model densitometer, FSN 6525-935-3640, shall be used exclusively. The MACBETH densitometer includes a built-in density calibration filter which can

be positioned in or out of the light path. This permits the operator to set the scale calibration by the flick of a lever, and eliminates the frequent use of the 21-step density calibration tablet furnished with the MACBETH densitometer. Densitometers other than the MACBETH are no longer under naval procurement. Kodak calibrated photographic step tablet number 3 with 21 steps ranging in density from approximately 0.02 to 3.9 should be obtained and used to calibrate the MACBETH densitometer. Once the densitometer is properly zeroed and calibrated with the standard density tablet, it can be used with BUMED calibration curves. The calibration of a densitometer is verified by checking at least one density step, preferably a density of mid-scale value. This verification should be made prior to film evaluation each day and the built-in density calibration filter should be utilized for the routine density calibration with each 15 films.

(b) *Availability.* The MACBETH GN-304 densitometer is available from the Medical Stores Section, U. S. Naval Supply Depot, Mechanicsburg, Pennsylvania. Instructions for use, care, and maintenance are prescribed in the manufacturer's manual which accompanies each densitometer.

(4) *Calibration Curves.*—Quality control calibration curves for Type 3 film are prepared by BUMED, Code 7421, prior to supply system release of each emulsion. Curves or correction factors will be distributed by BUMED for sensitivity variations greater than $\pm 15\%$. Notification of variations less than $\pm 15\%$ will not normally be made. Activities desiring to prepare their own calibration curves may do so, provided they submit evidence to BUMED, Code 7421, of high quality performance in calibration, processing, and evaluation of dosimetric film. Refer to Appendix B for information required by BUMED for granting permission to prepare calibration curves.

6-6. FILM PROCESSING PROCEDURES

(1) *Frequency.*—Film shall be processed according to the following schedules.

(a) *Kodak Type 3.* Kodak Type 3 film shall be processed and read monthly within 5 working days after film collection, or more frequently as deemed necessary. If monthly collection will produce short issue periods, because of operational commitments or other circumstances, the issue period may be extended as required for not more than 15 days. Under special circumstances of consistently low exposures, and with approval of the Radiation Health Officer, personnel film may be processed twice per quarter. Posted film will be evaluated at least quarterly. Additionally, in the case of personnel transferred or visitor's films during a badging period, the film may be retained for processing at the next regularly scheduled processing period and the exposure data forwarded upon completion of the evaluation of the film.

(b) *Neutron Film.* Neutron film shall be processed and read whenever a high radiation exposure is suspected, or as deemed necessary by the Radiation Health Officer. However, if neutron film is issued but not normally processed, at least five percent of

the issued personnel neutron film shall be evaluated each quarter. This film shall be selected from personnel receiving the highest gamma exposures where neutron exposure is probable, and from those with greatest access to neutron fluxes. Posted neutron film shall be evaluated quarterly or when an incident or accident occurs.

(2) *Processing Solutions.*—All dosimetric film shall be processed with Developer, X-ray Film Processing, Rapid Speed, Powder Kodak, dilute to 1 gallon (FSN 6525-168-1615); and Fixer, X-ray Processing Powder, Kodak, dilute to 1 gallon (FSN 6525-579-9112); or Developer, Film Processing, Kodak, dilute to 5 gallons (FSN 6525-935-4097); and Fixer, Film Processing, Kodak, dilute to 5 gallons (FSN 6526-935-4105) may be substituted, if desired. Deviation from the prescribed factors of mixture, time, and temperature will invalidate all calibration values and introduce serious error in exposure reading. Developing and fixing solutions must be made with distilled or demineralized water (according to instructions of the containers) and stirred with individual stirring rods. The temperature must be maintained at 68°F (20°C) with not more than $\pm 1^{\circ}\text{F}$ variation. Solutions will not be renewed by "spiking" with replenisher. Solutions should not be used to process more than 2500 films per gallon. Solutions may be kept for occasional use in light free, temperature controlled conditions (not to exceed 75°F) for up to one (01) month. Except in emergency cases, new solutions should be allowed to stabilize 24 hours before use. Processing tanks must be thoroughly scrubbed and rinsed when solutions are renewed.

(3) *Film Packets.*—Kodak Type 3 and Type A packets should be opened in total darkness. If necessary, a safelight may be used under the following conditions; (1) when using a Filter, Photographic Darkroom, Safelight (FSN 6525-612-7785), and; (2) when using a 7.5 watt frosted glass bulb. Keep the safelight not less than 4 feet from unwrapped film, and test to show that no density increase occurs when unwrapped film is exposed under these conditions for a period of 20 minutes. When darkrooms are equipped with any fluorescent lighting, these lights must be turned off at least 30 minutes before opening any film packets. This is necessary because of residual light which is often emitted from fluorescent lights after they have been extinguished. Films are placed in the film processing racks preferably by consecutive serial numbers with at least one control film packet included in each rack. All serial numbers should have been previously logged. The slow film, which lies behind the fast film, may be retained in the film packet, placed in a light-tight container, and stored for possible later development. If densities of the fast film are encountered which are 3.5 density units or greater, the slow film and slow control film shall be processed and evaluated.

(4) Processing Techniques

(a) *Developing.* Immerse film rack in the developer and agitate for 10 seconds to dislodge air bubbles clinging to the film surface. Agitate for 10 seconds at 1 minute intervals during the required developing

time to insure uniform film development. Develop Type 3 beta-gamma film and Type A neutron film for 5 minutes.

(b) *Rinse*. Immerse film rack in clean water at 65° to 70° F, and agitate for 10 seconds to remove developing solution from the film. Then immediately place the film rack in the fixer solution.

(c) *Fixing*. Agitate the film rack immediately upon immersion for 10 seconds. Room lights may be turned on after the films have been fixed for 10 minutes. Type 3 and neutron Type A film both require a 15-minute fixing time.

(d) *Washing*. After fixing Type 3 and neutron Type A films, they are washed in clear, clean tap water between 60° and 80° F for 30 minutes. Water flow shall be sufficient for at least 8 changes per hour in the volume of the wash container.

(e) *Drying*. All film shall be dried in dust-free air at temperatures not to exceed 120°F. Higher temperatures cause changes in film density. Drying time depends on air temperature and humidity, and may require 2 to 3 hours to dry and harden the emulsion in still air. Time may be shortened to as little as 30 minutes with a heated, forced air dryer.

6-7. FILM INTERPRETATION PROCEDURES

(1) *Type 3 Film Evaluation for Beta, Gamma, and X-ray*

(a) *Density*. The densitometer must first be zeroed and calibrated, as directed by the manufacturer's manual. Then the average density of each control film is determined by reading two or more points on the film. Each of the exposed films is then read in the center of the filter areas for the types of radiation to which the film was exposed and an average density for each filter area established and recorded.

The zero position and calibration of the densitometer should be rechecked every 15 films.

(b) *Evaluation*. All films should be evaluated under the open window and cadmium shield and the gross densities recorded. If the gross densities for these areas are within 0.03 density units of the control density, no significant exposure has occurred and it is not necessary to read the other filter areas of the film. If an increased gross density is recorded and the open window gross density is within ± 0.03 density units of the cadmium shield gross density, the exposure may be assumed to be from high energy (hard) gamma. An increase in gross density under the open window greater than 0.03 density units indicates exposure to beta, x-ray, or gamma rays of less than 0.2 MeV. The exposure from beta or x-ray is determined by subtracting the net cadmium shield density from the net open window density and referring to the appropriate calibration curve. Net densities within ± 0.03 units of the control in any filter area shall be evaluated as zero exposure. Columns on the worksheet shall be left blank if no evaluation of that filter area is actually made. The entry of zeros indicates that an evaluation has actually been made and no significant exposure has occurred. In distinguishing between beta and x-ray exposures, it is noted that

beta exposures produce an open window that is fuzzy in appearance, and the edges of the window are poorly defined. In contrast, x-ray exposures produce a sharply-defined open window, and the single steel and double steel areas are discernible. In the case of high energy x-rays, the cadmium plus steel and the cadmium shields are also well defined. Through the use of density ratios between the open window and the four shielded areas, it is possible to further differentiate between the type and effective energy of the exposure and to obtain correction factors for use with the calibration curve for more exact exposure evaluations. Further information about density ratios may be obtained from BUMED, Code 7421, upon request.

(c) *BUMED Calibration Curves*. The calibration curves published by BUMED are plotted in units of Roentgens for gamma and x-ray, and Rads for beta. Since the Quality Factor (QF) is one for beta, gamma, and x-ray, no correction is required and the value obtained from the calibration curve may be recorded as Rem. The calibration curves for thermal and fast neutrons are plotted as Rem and no additional correction is necessary.

(2) *Thermal Neutron Evaluation*.—Thermal neutron exposures in the range from 2 millirem to 10 rem are evaluated using the Kodak Personnel Monitoring Film, Type 3. Cadmium having a relatively high thermal neutron absorption cross-section in comparison to steel, emits an instantaneous capture gamma photon with the absorption of a thermal neutron. This photon causes an increased film density under the cadmium, but does not affect film density under the double steel. Therefore, the thermal neutron exposure is evaluated by entering the Thermal Neutron Calibration Curve (contained in Appendix C) with the cadmium minus double-steel density. Thermal neutron exposures greater than 10 rem must be evaluated using the Accident Dosimeter attached to the film holder. The Accident Dosimeter will be provided only to activities with special requirements.

(3) *Fast Neutron Exposures*

(a) *Fast Neutron Effect on Type A Film*. Fast neutron exposures from 30 mrem to 10 rem are evaluated using the Kodak Personnel Neutron Monitoring Film, Type A. The Type A film detects fast neutrons in an energy range from about 0.6 to 14 MeV by recoil protons producing ionization tracks in the film emulsion. A recoil proton of 0.3 MeV, resulting from the elastic collision of a 0.6 MeV neutron with a hydrogen nucleus, produces a track of 3 to 4 grains, in length (3 or 4 μ). To be counted, a track must consist of at least 3 adjacent grains. Since in most cases neutron radiation is accompanied by gamma radiation, it is not normally necessary to evaluate neutron film when there has been no exposure from gamma radiation.

(b) *Effect of Thermal-vs-Fast Neutrons on Type A Film*. The Type A film will detect thermal neutrons by reactions with nitrogen nuclei, $^{14}\text{N}(n,p)^{14}\text{C}$. The proton that results from this reaction has an energy of about 0.5 MeV, which produces a track of 8 to 10 grains in length (6 μ). These tracks will be

indistinguishable from tracks produced by recoil protons of the same energy. However, the response of the Type A film to thermal neutrons is less than for fast neutrons by an approximate factor of 20. Therefore, the Type 3 film will be used as previously described for thermal neutron exposures and all tracks on the Type A film will be considered as those resulting from a fast neutron exposure. There is virtually no response of the Type A film to neutrons between the energies of a few eV up to about 0.6 MeV.

(c) *Microscope Procedure*

(1) Fast neutron exposures are evaluated by counting the number of tracks in a given area of the Type A film with a microscope. A binocular microscope equipped with a mechanical stage, a light field condenser, and a lens system capable of 450X or greater magnifications, or a projection system of suitable magnification may be used for this procedure. Films may be read at any magnification from 450X to 1000X at which the operator feels comfortable and the tracks may be accurately identified. The films may be read either "high and dry" or oil immersion depending on the lens chosen. It must be remembered that the field size will vary with each magnification used, and use of "zoom" attachments will greatly vary the field size.

(2) The processed film should be placed in some suitable film holder to flatten the film and prevent slippage during reading. The film holder is placed on the microscope stage and raised slowly until the film grain is in focus. If the oil immersion lens is used, the oil is placed directly on the film. Starting at one end of the film, the mechanical stage is moved along the X-axis while continually oscillating the fine focus. Tracks of three or more adjacent grains will appear to have a "fishtail" effect. This effect is a diffuse appearance tailing off the emulsion grains and is due to the darkened grains at various depths in the emulsion going in and out of focus.

(3) Either discrete field counting or traverse scanning may be used. However, the total film area viewed must be known in either case. This may be accomplished by measuring the individual field size with a glass slide micrometer or a haemocytometer on which lines of definite dimensions are inscribed. Thus, knowing the area of one field, it then becomes a simple matter to compute the total area viewed.

(d) *Computing Exposures.* Control neutron film must be processed and read to establish the background occurrence of tracks. Normal control film background from cosmic rays runs 0 to 3 tracks per 1 mm² (approximately 50 fields). Issued film may then be read by viewing at least 0.5 mm² (approximately 25 fields). If two or less net tracks (gross tracks minus background tracks for the same area) are observed, disregard and enter the neutron exposure on the DD Form 1141 as zero. If three or more net tracks are observed, proceed to read at least 1.0 mm² (a total of approximately 50 fields). The number of tracks per unit of neutron exposure depends on the amount of film area viewed. One-half mm² is considered the minimum film area from which reliable screening results can be obtained. Based on

this procedure, a neutron exposure of 30 millirem (3 net tracks per mm²) is the minimum detectable dose, while 10 rem (1000 net tracks per mm²) represents the point at which tracks are too numerous to count. The accident dosimeter, DT-518/PD, will permit evaluations of neutron exposures up to 50,000 rem.

(e) *Special Considerations*

(1) New film should be procured if the expiration date has been passed, or if the background exceeds 5 tracks in 1.0 mm².

(2) When a high energy neutron (generally from cosmic rays) strikes the nucleus of a heavy atom present in the emulsion, an inelastic collision occurs, causing a spallation, or "thorium star." This will be seen as three or more tracks emanating from a single point and is counted as one track. When only two tracks are seen emanating from one point they are counted as two tracks.

(3) Track fading can be a problem with the Type A film. This occurs primarily with the delay in time between exposure and processing. Track fading is further increased when the film is used in areas of high humidity or temperature. This problem can be minimized by processing the film as soon as possible after a suspected or accidental exposure has occurred. There is negligible track fading once the film has been properly processed.

(f) *The Calibration Curve.* A fast Neutron Calibration Curve contained in Appendix C is furnished by BUMED (Code 7421) to evaluate exposures on the basis of net observed tracks. This curve provides for reading approximately 25 fields (0.5 mm²), 50 fields (1.0 mm²), 100 fields (2.0 mm²), and 200 fields (4.0 mm²). Reading a given number of fields must not be construed to be a specific area. In every case, the field size must be measured and the area calculated. If total areas other than the ones provided are used, millirem per track factor can be derived by dividing the total area viewed into 10. The standard calibration curve provided by BUMED is prepared on the basis of 5.5 n/cm²/sec being equivalent to one millirem per hour. This factor conservatively estimates neutron exposure for plutonium-beryllium sources and for a flux of fast neutrons penetrating the secondary shield of nuclear-powered ships.

6-8. COMMON FILM INTERPRETATION PROBLEMS

(1) *Common Physical Problems.*—Film that is old or has been exposed to extremes of temperature or humidity will exhibit mottled, spotty, or non-uniform densities. Film thus affected should not be used and should be reported in accordance with article 6-10 of this manual. Care should be taken, also, not to read film on the densitometer through a flaw, fingerprint, or one of the serial numbers. Assistance in evaluating problem film may be obtained by forwarding the film and all pertinent information to BUMED Code 7421.

6-9. ACCIDENT DOSIMETER

The range limitations on dosimetric film have made it necessary to devise a method to detect and measure

high exposures such as might be incurred in a nuclear accident. This capability has been incorporated into the Nuclear Accident Dosimeter, DT-518/PD, which is to be attached to the standard Navy film badge holder. The individuals who work in an area where nuclear accidents or high exposures are possible are required to wear accident dosimeters. The accident dosimeter has the capability of measuring neutron and gamma exposures from 10 rem to 50,000 rem and above. The accident dosimeter contains a sulfur pellet, an indium foil, and a thermoluminescent dosimeter (TLD 700 grade). The sulfur pellet will detect high energy neutrons by the $^{32}\text{S}(n,p)^{32}\text{P}$ reaction for neutron energies greater than 2 MeV. The resultant ^{32}P , 1.7 MeV beta particle can be counted with a G-M Counter, or the AN/PDR-27. Activation of the indium foil is a positive indication that the person has been exposed to neutrons. Thermal neutron exposures from less than 10 rem to the limit of the meter can be detected by the probe of the AN/PDR-27 from the radioactivity induced in indium. The thermoluminescent powder used is Lithium Fluoride, which is capable of detecting gamma ray exposures as high as 50,000 rem when read in a special TLD reader. Two Navy medical facilities have been assigned the processing and dose analysis of the DT-518/PD. The facilities are Radiation Safety Department, National Naval Medical Center, Bethesda, Maryland and Radioisotope Laboratory, Naval Hospital, Oakland, California. Instruction for the use and evaluation of the dosimeter is provided in NAVELEX 0969-133-1010 (Technical Manual for Radiac Detector DT-518/PD).

6-10. DIVER FILM BADGE HOLDER

Divers working in areas where exposure to penetrating radiation is possible shall be monitored in accordance with para. 6-1(1) using a standard Navy film badge holder. When the standard Navy film badge holder is used, it shall have the clip removed and be encased in a rigid plastic holder, which is watertight and will withstand the submergence pressures encountered. The device shall be worn on the front of the trunk of the body outside the clothing, and may be attached to belts or straps on the divers equipment in a manner most convenient to the diver.

Activities requiring this device may request plans for an acceptable diver film badge holder from BUMED, Code 7421. The device is watertight and pressure proof to any depth a diver may be expected to work. Specific instructions for evaluation of films for gamma and neutron radiation will be included with the plans.

6-11. FILM EVALUATION CHECKS

(1) *Evaluation Check Procedures.*—Because of the many variations possible in the processing and evaluation of dosimetric film, periodic procedural checks are required. These checks shall be made by processing and reading previously-exposed quality assurance films, and comparing the determined exposure

to the exposure the film was known to have received. Agreement with calibrated film must be within $\pm 25\%$ to be considered satisfactory.

(2) *Quality Assurance Film.*—Quality assurance films should be obtained by exposing film to known radiation doses from sources held by the activity or its support organization. If quality assurance films cannot be obtained in this manner, they may be requested from BUMED, Code 7421. Quality assurance films should be processed as soon after exposure as practical.

(a) *Beta-Gamma.* Beta-gamma quality assurance films may be exposed using a TS-1189/PD Dosimeter Tester or other calibrated gamma sources. The film in a film badge holder should be placed face down with the cadmium shield across the open top of the tester for a period long enough to produce an exposure of at least 150 mrem of gamma. The dose rate is initially determined by placing the high range detector probe of a newly calibrated AN/PDR-27 horizontally across the open top of the tester. After processing, only the middle portion of the cadmium shielded area of the film should be evaluated. The tester's cesium source, in its position in the shield, will give rise to a significant fraction of low energy photons, for which the film under the cadmium shield will be more responsive. Therefore, since the film is evaluated by entering the Cobalt-60 gamma curve with the net "cadmium density," the resulting dose must be multiplied by a 0.75 correction factor. The 0.75 correction factor is used only for exposures made using the TS-1189.

(3) *Required Frequency of Quality Assurance Checks.*—A minimum of two beta-gamma quality assurance films shall be processed and read each month. Additionally, just prior to issue of film from a newly acquired shipment of Type 3 film, each activity should expose and evaluate at least two representative films as described above to check film sensitivity and for possible defects. In all cases where possible, processing personnel should not know the dose the film received prior to evaluating the film.

(4) *Additional Checks.*—Prior to processing film, checks of related chemicals and equipment should be made. Such checks should include the following items:

(a) *Thermometer.* The darkroom thermometer should be compared with several other thermometers so as to demonstrate a probable accuracy of $\pm 1^\circ\text{F}$. in the 68°F . range.

(b) *Solutions.* Processing solutions shall be prepared with distilled or demineralized water, and must be within proper age and temperature parameters. Solutions must be clear and free of foreign material.

(c) *Densitometers.* Densitometers must be checked prior to use for proper operation, including "zero set" and density calibration.

(5) *Required Records and Reports.*—Each use of quality assurance film will be recorded including the film exposure, the estimated dose, and the percent error. If errors greater than $\pm 25\%$ are noted, the circumstances producing the error must be investigated, corrected, and recorded by the Radiation Health

Officer or designated local authority. If such errors cannot be explained and corrected locally, a letter report, Film Exposure vs Film Interpretation Error Report MED 6470-6, giving full details must be submitted promptly to BUMED, Code 74. Similarly, differences between film badges and dosimeter measurements should be recorded. Differences should be less than $\pm 25\%$ for exposures greater than 150 mrem as determined by film badge. To ensure accurate dosimetry, differences greater than $\pm 25\%$ should be investigated and resolved. Because of statistical errors associated with these measurements, some differences between 25 and 35% can occur even though proper procedures are used. However, these differences should be few in number. A Film Interpretation vs Pocket Dosimeter Error Report (MED 6470-7), detailing differences greater than $\pm 35\%$ between pocket dosimeter and film badge measurements for exposures greater than 150 mrem as determined by film badge should be reported to BUMED, Code 74, if the organization involved cannot determine the cause of the discrepancies.

(6) *Photodosimetry Audits.*—To ensure that the regulations, procedures, and checks specified herein are appropriately complied with, semi-annual photodosimetry audits will be conducted. For forces afloat, these audits shall be made by Squadron Medical Officers, their equivalents, or their designated representatives. Shore based activities should conduct their own audits by utilizing personnel as inspectors who are knowledgeable in the Radiation Health field, but who are as independent as possible of the local photodosimetry program. Additional audits may be

held as directed by District Medical Officers, or by BUMED, Code 74. Discrepancies noted on photodosimetry audits shall be reported to BUMED, Code 74, by Photodosimetry Audit Discrepancy Report, MED 6470-8.

(7) *Reporting of Other Photodosimetry Discrepancies.*—In field or fleet activities, discrepancies in photodosimetry results sometimes occur due to defective film, defective processing chemicals, or other technical fault. If an occurrence of this nature should arise, a report of the discrepancy shall be made by letter to BUMED, Code 7421, and if caused by defective material the report required by FLDBR-BUMED-FMSOINST 6700.16 series must be submitted to the cognizant supply center. The reports should include emulsion number or lot number, expiration date, and any other available information.

6-12. ESTIMATING EXPOSURE IN LIEU OF FILM BADGE DATA

Exposure estimates from defective, damaged, or improperly processed film must be considered as inconclusive for record purposes. Lost badges cause data to be lacking for certain exposure periods. In these cases, personnel exposures should be estimated from, (a) pocket dosimeter indications, (b) recorded radiation levels and exposure times, and (c) exposure of other personnel doing similar work. Only in cases where an educated estimate of radiation exposure cannot be obtained is it necessary to assign a 1.25 rem/quarter dose as discussed in article 5-2(1) (a).

Chapter 7

STORAGE, HANDLING AND DISPOSAL

	Article
Requirements	7-1
Monitoring	7-2
Control of Areas	7-3
Control of Radioactive Materials	7-4
Waste Disposal	7-5

7-1. Requirements

The storage, handling, transportation and disposal of radioactive materials involve very serious and insidious health hazards and must be subject to regulation so that personnel will not be exposed to radiation unnecessarily.

7-2. Monitoring

Monitoring to determine and control radiation levels, airborne radioactivity and surface contamination should be performed as necessary in radiation and high radiation areas, and in contaminated and surrounding areas. Records of such surveys should be maintained.

7-3. Control of Areas

(1) *Unrestricted Areas.*—There should not exist in unrestricted areas radiation levels which would be likely to cause any individual to receive a dose of ionizing radiation in excess of those limits specified in paragraph 4-3. (3).

(2) *Radiation Areas.*—Radiation areas are defined in article 1-5(10). Such areas should be posted conspicuously with signs bearing the standard radiation symbol and the words "Caution" (or "Danger"), "Radiation Area." Additional precautions or information such as "No Loitering," "No Bunking," stay-time limits, or radiation levels may be added to the signs. Dosimetric devices should be used in the radiation areas to meet the criteria established in articles 6-1 and 6-2.

(3) *High Radiation Areas.*—High radiation areas, as defined in article 1-5(11) should be posted conspicuously with signs bearing the standard radiation symbol and the words "Caution" (or "Danger"), "High Radiation Area," "No Entry by Unauthorized Personnel." Additional precautions, stay-time limits, or radiation levels may be included. Dosimetric devices, as defined in article 6-2, should be worn by all personnel entering high radiation areas.

(4) *Contaminated Areas.*—A contaminated area includes any area in which the loose contamination

exceeds the limits as defined in article 1-5(8). Provision for donning and removing anticontamination clothing and masks should be available at the points of entry and egress to such areas. Control measures such as monitoring, decontamination and isolation should be used to prevent spread of contamination to uncontrolled areas, to protect personnel in the contaminated area, and to stay within the limitation of maximum permissible concentrations of radio-nuclides referred to in article 4-4(2).

(a) *Anticontamination Clothing and Masks.* Each naval activity at which radioactive materials are handled should provide protective clothing for personnel entering a contaminated area. The type and amount of clothing required will vary with the local situation. The appropriate mask should be worn when the concentration guides for radionuclides, as referred to in article 4-4(2), are likely to be exceeded.

7-4. Control of Radioactive Materials

(1) *Licensed Materials.*—Regulations covering the possession and use of AEC licensed radioactive materials are contained in the Code of Federal Regulations, Title 10. Naval activities are not subject to the licensing requirements of individual States. Naval activities requiring AEC licenses should submit their requirements and a request for appropriate license application forms and instructions to the cognizant command, office, or headquarters exercising management control over the activity. License applications should show compliance with all applicable provisions of the Code of Federal Regulations, Title 10, and should be submitted via the cognizant command, office, or headquarters. The application shall contain an original and 1 copy for Byproduct Material License applications, an original and 3 copies for Source Material License applications, an original and 5 copies for Special Nuclear Material License applications. (At least one copy in addition to those above should be enclosed for Command use.) After appropriate review, the cognizant command, office, or headquarters forwards the approved original and two copies of the application to the AEC Division of

Licensing and Regulation for action. If approved by the AEC, the license is returned to the cognizant command, office, or headquarters which then forwards the final approved AEC license to the originating activity, noting any special conditions or restrictions imposed by the AEC. The Chief, BUMED, has been assigned responsibility for coordinating applications for activities under its management control. The Headquarters, U. S. Marine Corps, coordinates applications for Marine Corps activities. The Chief, NAVMAT, has been assigned responsibility for coordinating applications for activities under NAVMAT's management control. Advice and assistance for all applicants under NAVMAT's management control is available by contacting the Navy Radiological Affairs Support Office, Autovon 345-6316 (Address: OIC (ATTN RASO), Naval Nuclear Power Unit, P. O. Box 96, Fort Belvoir, Virginia 22060. NOTES: 1. Unless otherwise directed by NAVMAT, field activities do not require AEC license for radioactive sources in radiac equipment supplied by NAVELEX, since these sources are held under AEC license to NAVELEX. 2. Unless otherwise directed by NAVMAT, field activities do not require an AEC license to issue, store, use, or ship items containing by-product material for which an AEC specific license has been granted to Naval Supply Systems Command. 3. Unless otherwise directed by the Headquarters Marine Corps, field activities do not require AEC licenses for radioactive sources in depth gauges and compasses distributed through the Marine Corps Supply System since these sources are held under AEC license to Headquarters Marine Corps.)

(2) *Non-licensed Materials.*—By authority of the Atomic Energy Act, special nuclear materials associated with military weapons are not subject to AEC licensing. In addition, special nuclear materials and radioactive byproducts associated with naval nuclear propulsion plants are not subject to AEC licensing, but are controlled in accordance with NAVSHIPS INSTRUCTIONS 9890.10 and 9890.12. Naturally occurring radioisotopes and accelerator-produced radioisotopes are also not under AEC license control.

(3) *Marking.*—Military requirements for marking radioactive materials (including radium) are contained in Military Standard MIL-STD-1458. These requirements are consistent with the marking requirements of the Code of Federal Regulations, Title 10. Any item in the Navy, not already marked in accordance with MIL-STD-1458 which exhibits a radiation level of more than one-tenth of one milliroentgen per hour above natural background at a distance of approximately one inch from the item, should be treated as radioactive. Whenever such items are stored or used in uncontrolled areas they should be marked with the standard radiation symbol and the words, "CAUTION: Radioactive Material." In uncontrolled areas, this marking should be used on any material which is contaminated with radioactivity in excess of the surface contamination criterion set forth in article 1-5(8).

(4) *Transfer and Accountability.*—Radioactive material licensed by the AEC should be transferred

only: (a) to persons currently licensed by the AEC or by a State to possess the specific type and quantity of material, or (b) to persons authorized to receive the material by virtue of a license held by the cognizant command, office, or headquarters exercising management control (e.g., certain radioactive sources in radiac equipment supplied by NAVELEX.) Radioactive material associated with naval nuclear propulsion plants should be transferred only to activities authorized to handle such materials in accordance with NAVSHIPS INSTRUCTION 9890.12. To ensure against loss, materials requiring a Type II marking by MIL-STD-1458 should be accounted for at all times. These and other materials marked in accordance with article 7-4(3) above should be accounted for when transferred outside controlled areas. Receipts should be obtained for transfer of such materials to other organizations. Waste materials which are marked as radioactive must be disposed of as radioactive waste in accordance with article 7-5 below.

(5) *Transportation.*—Transportation of radioactive materials should be in accordance with applicable portions of the following regulations or documents:

Title 49 CFR Parts 171-179 Department of Transportation regulations for shipment by rail or highway.

Title 14 CFR Part 103 Federal Aviation Agency regulations for shipment by air.

Title 46 CFR Part 146-U. S. Coast Guard regulations for shipment by water.

Title 39 CFR Part 15-U. S. Postal Regulations for shipment by mail.

NAVSUP PUB 505—Packaging and Handling of Dangerous Materials for Transportation by Military Aircraft.

(6) *Decontamination.*—Information concerning specific decontamination procedures may be obtained from the appropriate NAVSHIPS and NAVFAC publications.

(7) *Radiography.*—Radiographic sources should be handled in accordance with the Code of Federal Regulations, Title 10, Part 34.

7-5. Waste Disposal

Disposal of radioactive waste presents potential hazards to the public. Regulations issued by the Atomic Energy Commission contain certain requirements which must be met by persons engaged in radioactive waste disposal operations. A number of experienced commercial organizations which meet these requirements are licensed by the Atomic Energy Commission or by certain States to dispose of radioactive wastes.

(1) *Normal Procedure.*—Naval activities should dispose of radioactive wastes in accordance with NAVSUP INST 5101.9 (NAVSUPCEN Norfolk and Oakland are Navy disposition control points for radioactive waste materials.)

(2) *Exceptions.*—The following are exceptions to the above:

(a) The procedures of NAVSHIPS 389-0153 and NAVSHIPS 389-0288 should be followed in the

disposal of radioactive liquid effluents from naval nuclear-powered ships, their tenders, and supporting shipyards.

(b) If they meet the requirements of paragraph 20.303 of the Code of Federal Regulations, Title 10, Part 20, small amounts of low activity wastes may be disposed of through sanitary sewerage systems.

(c) If the foregoing disposal guidance cannot be met, contact the Chief of Naval Operations (OP-985) for guidance.

(3) *Records.*—It is required that records be kept of the quantities of waste transferred to AEC or State-licensed commercial activities for final disposal. Annually, as of 31 December, a summary of these records

should be forwarded to the cognizant management activity, with a copy to Chief of Naval Operations, Atomic Energy Division (OP-985). Disposal of special nuclear material must be documented in accountability records. Guidance for retention of these records should be kept in accordance with SECNAV INST P-5212.5 series, Disposal of Navy and Marine Corps Records. The requirements for documentation and approval of disposal of special nuclear material used in connection with naval nuclear-powered ships are described in NAVSHIPS INST 9890.10.

(4) *Funds.*—Accounting instructions for radioactive waste disposal are contained in NAVSUP INST 5101.9.

APPENDIX A—REPORTING FORMS

DD 1141 Record of Occupational Exposure to Ionizing Radiation

NAVMED 6470/1 Exposure to Ionizing Radiation, Report Symbol 6470-1 or 6470-2

STANDARD FORM 600—Overprint for Radiation Physical Examination

[illegible]

PREVIOUS EDITIONS ARE OBSOLETE.

S/N-0101-804-6002

INSTRUCTIONS FOR PREPARATION OF DD FORM 1141

ITEM

1. Enter file, service, badge, check, or clock number by which individual is currently identified.
2. Enter last name, first name, and middle initial. If the combination of last name and first name exceeds 19 spaces, enter last name and initials only.
3. Enter Social Security number.
4. Enter in not more than 10 spaces, rank, rate, grade, title or position that the individual is currently holding. Use standard service abbreviations, e.g., CAPT; MC; HMCS; HM1; SSGT; LCPL; etc. Abbreviate civilian occupation titles as necessary; e.g., Radiological Physicist to Rad Physic; Radiation Physiologist to Rd Physiol; Electrical Welder to Elec Wldr; etc.
5. Enter date of birth by day, month, and year, e.g., 21 Sep 1918.
6. Enter name of activity or unit.
- 7 and 8. "Period of Exposure." Enter the day, month, and year, e.g., 1 Oct 62.
7. Enter the day, month, and year exposure period began.
8. Enter day, month, and year exposure period ended.
- 9 through 12. "Dose This Period." Enter radiation dose received this period to three decimal places, e.g., 02.345 rem. All entries shall be made using five digits including zeros as necessary.
9. Enter skin dose (*soft*) which includes low energy gamma and x-ray of less than 20 KEV effective energy and beta radiation. Total skin dose is the visual addition of columns 9 and 12.
10. Enter gamma and x-ray dose greater than 20 KEV effective energy in rem.
11. Enter Neutron dose in rem.
12. Enter sum of items 10 and 11.
13. Add item 12 to previous item 13; enter total in item 13.
14. Enter permissible dose calculated from the age formula $5(N-18)$ rem, where N equals the present age in years.
15. Recorder certify entries by initialling.
16. Enter other pertinent information such as known exposure from internally deposited radioactive material or from any external radioactive sources. Describe briefly any activity or assignment bearing a potential for exposure and estimate dose-time relationships, if feasible. If this form is used for other than whole body and skin of whole body, specify the use; i.e., hands and forearms, feet and ankles, thyroid, etc. When recorded dose is not obtained from film badge readings, specify whether estimates were obtained from pocket dosimeters, area or air monitoring, bioassay, etc.

NOTE:

This record is required on all individuals who are employed by or are members of the Armed Forces and who have been or are being occupationally exposed to ionizing radiation. It shall be the responsibility of each activity of the Department of Defense having personnel so exposed to initiate and maintain this record in accordance with AR 40-14/BUMEDINST 6150.18 series/AFR 161-8/DSAR 4145.24. (29 Sept. 1966)

EXPOSURE TO IONIZING RADIATION
 MAYMED 6470/1 (5-70) (For instructions, see
 S/N 0105-214-5000 reverse side of sheet)

☐ REPORT OF PERSONNEL EXPOSURE TO IONIZING RADIATION

(REPORT SYMBOL MED 6470-2)

☐ REPORT OF PERSONNEL EXCEEDING RADIATION EXPOSURE LIMITS

4. DATE PREPARED

	ACCUMULATED DOSE
0-100 mg	100%
100-200 mg	98%
200-300 mg	96%
300-400 mg	94%
400-500 mg	92%
500-600 mg	90%
600-700 mg	88%
700-800 mg	86%
800-900 mg	84%
900-1000 mg	82%
1000-1100 mg	80%
1100-1200 mg	78%
1200-1300 mg	76%
1300-1400 mg	74%
1400-1500 mg	72%
1500-1600 mg	70%
1600-1700 mg	68%
1700-1800 mg	66%
1800-1900 mg	64%
1900-2000 mg	62%
2000-2100 mg	60%
2100-2200 mg	58%
2200-2300 mg	56%
2300-2400 mg	54%
2400-2500 mg	52%
2500-2600 mg	50%
2600-2700 mg	48%
2700-2800 mg	46%
2800-2900 mg	44%
2900-3000 mg	42%
3000-3100 mg	40%
3100-3200 mg	38%
3200-3300 mg	36%
3300-3400 mg	34%
3400-3500 mg	32%
3500-3600 mg	30%
3600-3700 mg	28%
3700-3800 mg	26%
3800-3900 mg	24%
3900-4000 mg	22%
4000-4100 mg	20%
4100-4200 mg	18%
4200-4300 mg	16%
4300-4400 mg	14%
4400-4500 mg	12%
4500-4600 mg	10%
4600-4700 mg	8%
4700-4800 mg	6%
4800-4900 mg	4%
4900-5000 mg	2%
5000-5100 mg	1%
5100-5200 mg	0%
5200-5300 mg	0%
5300-5400 mg	0%
5400-5500 mg	0%
5500-5600 mg	0%
5600-5700 mg	0%
5700-5800 mg	0%
5800-5900 mg	0%
5900-6000 mg	0%
6000-6100 mg	0%
6100-6200 mg	0%
6200-6300 mg	0%
6300-6400 mg	0%
6400-6500 mg	0%
6500-6600 mg	0%
6600-6700 mg	0%
6700-6800 mg	0%
6800-6900 mg	0%
6900-7000 mg	0%
7000-7100 mg	0%
7100-7200 mg	0%
7200-7300 mg	0%
7300-7400 mg	0%
7400-7500 mg	0%
7500-7600 mg	0%
7600-7700 mg	0%
7700-7800 mg	0%
7800-7900 mg	0%
7900-8000 mg	0%
8000-8100 mg	0%
8100-8200 mg	0%
8200-8300 mg	0%
8300-8400 mg	0%
8400-8500 mg	0%
8500-8600 mg	0%
8600-8700 mg	0%
8700-8800 mg	0%
8800-8900 mg	0%
8900-9000 mg	0%
9000-9100 mg	0%
9100-9200 mg	0%
9200-9300 mg	0%
9300-9400 mg	0%
9400-9500 mg	0%
9500-9600 mg	0%
9600-9700 mg	0%
9700-9800 mg	0%
9800-9900 mg	0%
9900-10000 mg	0%

4. TOTAL

LIFETIME
(REM)
CC 76-80

CC 29-37

17. APPROVED: (Radiation Health Officer or Medical Officer)

TITLE

INSTRUCTIONS

Personnel Exposure to Ionizing Radiation (Report Symbol MED 6470-1)
Personnel Exceeding Radiation Exposure Limits (Report Symbol MED 6470-2)

1. General

a. This dual purpose form may be used for either report but the reports must not be combined on the same form.

b. These reports are required on all personnel in the Naval Establishment who have been or are being occupationally exposed to Ionizing Radiation. It shall be the responsibility of each activity of the Naval Establishment having personnel so exposed to submit these reports to BUMED, Code 74, in duplicate in accordance with the following time periods.

1. Report Symbol MED 6470-1 - Report of Personnel Exposure to Ionizing Radiation shall be submitted annually to BUMED, Code 74, in duplicate by 31 January each year and shall include all personnel on board 31 December who incurred such exposure at any time during the calendar year at the reporting activity.

2. Report Symbol MED 6470-1 - Report of Personnel Exposure to Ionizing Radiation must also be prepared and submitted as a situational report if an individual so exposed was transferred, or terminated employment during the calendar year. This report shall be submitted to BUMED, Code 74, in duplicate by the activity at which the exposure was incurred, within 6 weeks of such transfer or termination. Data for the Report Symbol MED 6470-1 shall be obtained from the individual's DD 1141, Record of Occupational Exposure to Ionizing Radiation.

3. Report Symbol MED 6470-2 - Report of Personnel Exceeding Radiation Exposure Limits is required on all personnel in the Naval Establishment who have exceeded radiation exposure limits. It shall be the responsibility of the activity at which the limits were exceeded to submit this report in duplicate to BUMED, Code 74. A copy of the report shall be attached to each individual's DD 1141 for permanent retention. If personnel have received a dose of more than 3 rem in any one calendar quarter, the report shall be forwarded within 30 days from the determination of such exposure. If personnel have received a dose of more than 5 rem in a single incident, a report shall be forwarded within 24 hours from the determination of such exposure. If any individual has received a dose of more than 25 rem in a single incident, Chief, Bureau of Medicine and Surgery, shall be notified immediately by priority message.

2. Specific Coding Instructions

a. Check the appropriate boxes to indicate which report is being submitted and if the report being submitted is an Annual or Situational Report.

b. Item.

1. Enter name and address of reporting activity.

2. Enter Reporting Facility Code. Refer to Chapter 5 of the Radiation Health Protection Manual for instructions for devising the Reporting Facility Code.

3. Enter Calendar Year Reported.

4. Enter Date Reported.

5. Enter Name as currently carried on rolls - last name, first name, and middle initial, as appropriate. If this combination exceeds 19 spaces, enter last name and initials only.

6. Enter individual's Social Security Account Number.

7. Enter individual's year and month of birth.

8. Enter year, month and day exposure was considered to have started, i.e. 69-10-27.

9. Enter year, month and day exposure was considered to have ended i.e. 69-12-26.

10. through 14. Enter radiation doses received to three decimal places, i.e. 03.450. Enter doses evaluated as "zero" as 00.000. Do not use "X's" or term minimal.

10. Enter "Skin Dose", soft in rem (Roentgen Equivalent, Man) which includes low energy Gamma, X-ray of less than 20 KEV effective energy and Beta radiation.

11. Enter X-ray and Gamma dose in rem.

12. Enter Neutron dose in rem.

13. Enter accumulated dose for this period; sum of items 11 and 12.

14. Enter total lifetime accumulated dose in rem.

15, 16, 17. Self Explanatory.

Reporting Procedures are explained in detail in Chapter 5 of NAVMED P-5055, Radiation Health Protection Manual.

A-29254

*U.S. GOVERNMENT PRINTING OFFICE: 1970-433-463/120

HEALTH RECORD	CHRONOLOGICAL RECORD OF MEDICAL CARE								
DATE	SYMPTOMS, DIAGNOSIS, TREATMENT, TREATING ORGANIZATION (Sign each entry)								
	RADIATION PHYSICAL: ☐ PREPLACEMENT ☐ ANNUAL ☐ TRIENNIAL ☐ TERMINATION CONDUCTED IN ACCORDANCE WITH CHAPTER 2, NAVMED P-5055								
	1. HISTORY:								
	Exposure to Radiation Therapy				Previous Radiation Worker				
	Bleeding Tendency				Eye Disease				
	Malignancy				Weight Loss				
	Swollen Glands				Thyroid Disease				
	Family History of Cancer, Leukemia, Hodgkin's Disease, Cataracts								
	2. PHYSICAL EXAMINATION:								
	Abnormalities Noted: (Use Other Side If Necessary)								
	3. EYE EXAMINATION:								
	Slit Lamp Examination (Describe Abnormalities and Record Diagrammatically. (Use Other Side If Necessary).								
	4. HEMATOLOGY:								
	HGB	HCT	WBC	NEUT	BAND	LYM	MON	EOS	BAS
	5. WHOLE BODY COUNT: Lung Scan For Cobalt 60 _____ Nanocuries								
	6. This Employee is () QUALIFIED, () TEMPORARILY DISQUALIFIED or () PERMANENTLY DISQUALIFIED For Work in Radiation Areas.								
	M.D. Medical Examiner								

PATIENT'S IDENTIFICATION (Use this Space for Mechanical Imprint)

PATIENT'S NAME (Last, First, Middle initial)				SEX
YEAR OF BIRTH	RELATIONSHIP TO SPONSOR	COMPONENT OR STATUS	DEPARTMENT OR SERVICE	
SPONSOR'S NAME			RANK/GRADE	
SVC OR IDENTIFICATION NO.		ORGANIZATION		

S/N 0109-201-6901

CHRONOLOGICAL RECORD OF MEDICAL CARE

Standard Form 600
 February 1969
 General Services Administration and
 Interagency Comm. on Medical Records
 FPMR 101-11.809-3
 600-103

TO BE RETAINED PERMANENTLY IN HEALTH RECORD

APPENDIX B

INFORMATION REQUIRED BY BUMED FOR PERMISSION TO PREPARE CALIBRATION CURVES

- A. Statement of justification.
- B. Type or types of calibration curves to be prepared.
- C. Exposure range to be covered.
- D. Describe film holder to be used, include filter materials and thicknesses.
- E. List sources available and description of each:
 - 1. Gamma—Bureau of Standards calibration certificate and/or Bureau of Standards calibrated instruments used for measurement of output.
 - 2. Beta—If natural uranium plaque or uranium oxide ore is used, state output and conditions of exposure; i.e., if film is exposed bare or in the film holder. If other beta sources are used, state method of determining output.
 - 3. X-ray—List KVP, added filtration, determined HVL, and KEV effective. Include Bureau of Standards calibrated instruments used for measurement of output.
 - 4. Neutron—Source certification by Bureau of Standards and/or manufacturer. Include all calculations and conversion factors.

NOTE: If thermal neutron calibrations are attempted, describe the method in detail.

- F. Describe calibration equipment:
 - 1. Submit sketch of equipment setup; to include, source to film distance and distances between equipment, deck, and bulkheads.

NOTE: If fixed time and varying distances is the method of choice, list each distance.

- G. Describe processing unit:
 - 1. Make and model of processing tank including temperature maintaining capability.
 - 2. Type developer and fixer used, and frequency of renewal.
 - 3. List processing times for developing, rinsing, fixing, and washing.

- H. Evaluation methods:
 - 1. Density measurements—Make and model of densitometer. Year of make and date of last maintenance. Availability of calibration wedge. Frequency of densitometer calibration.
 - 2. Microscope technique—Make and model microscope. Magnification and type of condenser used. Include viewing method; i.e., direct, projection, television, etc. State the area of one field of view. In addition, list the number of fields and/or the total film area viewed.
- I. Submit samples of calibration curves.

APPENDIX C—CALIBRATION CURVES

DOSIMETRIC FILM CALIBRATION CURVE, GAMMA

DOSIMETRIC FILM CALIBRATION CURVE, X-RAY

DOSIMETRIC FILM CALIBRATION CURVE, BETA

DOSIMETRIC FILM CALIBRATION CURVE, THERMAL NEUTRONS

DOSIMETRIC FILM CALIBRATION CURVE, FAST NEUTRONS

